A TEXT BOOK

OF

PUNJAB AGRICULTURE

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INTRODUCTION

The Text Book of Punjab Agriculture was first published in 1921 and written jointly by Mr. O. T. Faulkner, C.M.G. and myself when we were colleagues at Lyallpur—I as Professor of Agriculture and Mr. Faulkner as Associate Professor. The book was out of print by 1936 and its revision was contemplated and actually started in 1937-38 by myself in collaboration with Mr. (now Sir) Herbert Stewart, the Director of Agriculture, and Sardar Bahadur S. Kartar Singh, Assistant Director of Agriculture. With the incidence of the war and later the transfer of Sir Stewart from the Punjab and also shortage of paper, the revision was abandoned. The work was started again in 1944 at the urgent request of the publishers.

The present Book, though based on the original Text Book, has been almost completely re-written. There has been vast development in our knowledge of Punjab Agriculture since 1921. New matter has been added in the form of general observations. Altogether the book is about 3 times the original in size and contents. As there have been much drastic re-writing and many additions Mr. Faulkner kindly agreed that his name should not be associated with the revised book. Most of the drudgery and drafting has been done by Sardar Bahadur Sardar Kartar Singh. We threshed out together many points of difference and always arrived at an agreed interpretation. The work has been a privilege and a great pleasure to me.

We have freely drawn upon the material published by the various sections of the Punjab Agricultural Department in journals, departmental leaflets, and other publications. The authors' thanks are due to every section. We are specially indebted to Dr. Arjan Singh, Marketing Officer Punjab for collection of numerous data and general assistance particularly in correcting proofs and preparing the index. The Irrigation Department have kindly allowed us to use the Irrigation map facing page 184. A comprehensive Text Book of Punjab Irrigation would be invaluable for the Punjab student, and we commend the idea to the notice of the Department.

There will no doubt be many mistakes in this Text Book—the Authors have done their best to make them as few as possible and crave indulgence for what they have missed spotting.

SIR WILLIAM ROBERTS.

PART I.—General

CHAPTER I

GENERAL FEATURES OF THE PROVINCE

The Punjab is a province in North-West India, comprising an area of 138,105 square miles, of which 39,016 square miles belong to Indian States. It, thus, forms one tenth of the area of the Indian Empire. It lies between 27° 39′ and 34° 2′ N. and 69° 23′ and 79° 2′ E. The latitude of Gibraltar in the south of Spain is 36°, or only 2° further north from the Equator than Attock in the north of the Punjab and 5° further north than Lahore. The Punjab is, however, an inland province with its capital, Lahore, 750 miles from the sea, and is hence subject to extremes of temperature of the continental character.

Physical divisions.

The Province falls into five main physical divisions, of which two—*viz.*, the Himalayan and the Salt Range arid plateau, are less important from the agricultural point of view. The remaining three are—

(*a*) The sub-montane, including stations such as Ambala, Hoshiarpur, Gurdaspur and Sialkot, forming the richest part of the Province.

(*b*) The Indo-Gangetic Plain West extending eastward as far as Lahore. It includes such Districts as Shahpur, Jhang, Lyallpur, Montgomery, and Ferozepore.

(*c*) The south-western arid plains, comprising Mianwali, Muzaffargarh, Dera Ghazi Khan and Multan.

The last two divisions are of vast extent and depend almost entirely on canal irrigation for their prosperity.

The Punjab, barring the montane and parts of the submontane tract, is in the main a vast level alluvial plain, with a gentle slope of about 1 foot per mile from east to west.

The Province is fortunate in having seven large rivers passing through it or along its boundaries. These are: (1) the Jumna, forming its eastern boundary for 200 miles and flowing into the Bay of Bengal; (2) the Sutlej, which enters the plains at Rupar and joins the Beas at Sobraon (Ferozepore); (3) the Beas which enters the plains just south of the Ravi, and then turns south and joins the Sutlej; (4) the Ravi, which reaches the plains below Dalhousie and joins the combined rivers of the Chenab and Jhelum 50 miles south of Jhang; (5) the Chenab, which reaches the plains east of Jhelum and joins the Jhelum river 225 miles further west; (6) the Jhelum, which enters the Punjab east of the Salt Range and joins the Chenab near Jhang; and (7) the Indus, which is the largest of all, and traverses partly through the Province and partly on its boundary. The combined Sutlej and Beas join the combined Jhelum, Chenab and Ravi at Punjnad, 8 miles north of Uch, and 270 miles south-west of Sobraon. The combined five rivers join the Indus in the south-west Punjab.

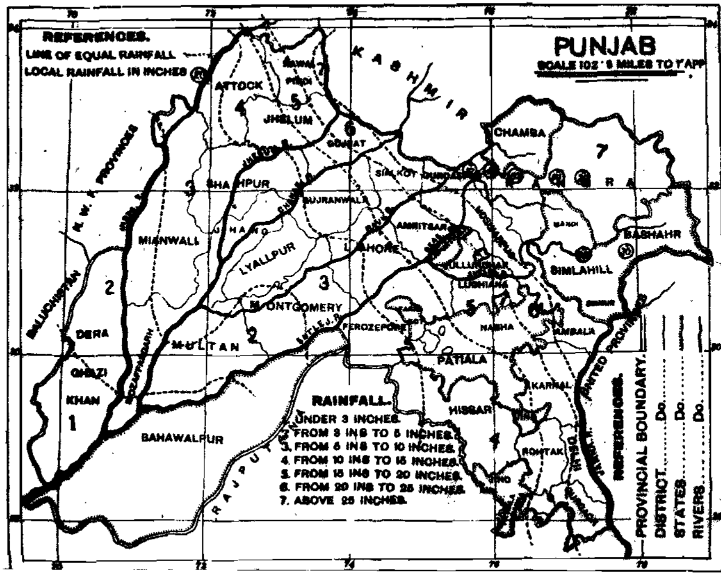
Of the seven rivers affecting the Punjab, therefore, six ultimately join within the Province. These rivers derive their supply of water mainly from melting snow in the Himalayas, and are in flood from April to September, when they carry enormous volumes of water. Their minimum winter supplies vary from 1,300 cusecs in the case of the Ravi to 18,000 cusecs in the case of the Indus at Attock.*

*Note by Mr. H. M. Nicholson Punjab Irrigation:

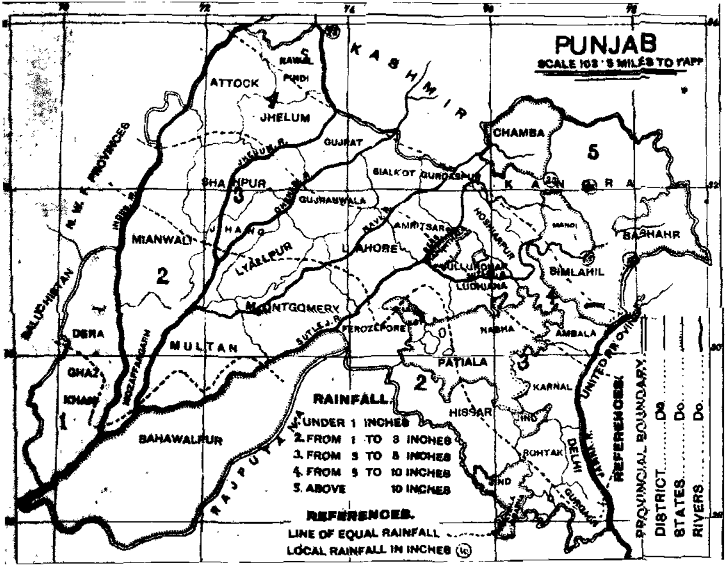
Statement showing the reported discharges of the Punjab Rivers.

River.	Site.	Minimum.	Maximum.
		Cusecs.	Cusecs.
Jumna	Tajewala	2,167	2,50,000
Sutlej	Rupar	2,818	2,60,000
Beas	Nowshera	2,800	3,25,000
Ravi	Madhopur	1,300	2,00,000
Chenab	Khanki	3,884	6,00,000
Jhelum	Rasul	4,500	5,00,000
Indus	Attock	18,000	10,00,000

The maximum flood means nothing to any one except the engineers who has design to pass that supply, which at the most will only be realised once in 30 year say, for a few hours. The supply from April to September is, however, generall from five to ten times the minimum winter supply.



MAP A SHOWING AVERAGE RAIN-FALL IN INCHES IN THE PUNJAB IN THE MONTHS JUNE TO SEPTEMBER



MAP B SHOWING AVERAGE RAINFALL IN INCHES IN THE PUNJAB IN THE MONTHS OCTOBER TO MAY

Over the greater part of the Punjab, summer temperatures are very high and winter temperatures very low. In December and January the temperature at night is often below freezing point, and crops may be damaged by frost as early as 20th November or as late as end of February. The day temperature in winter seldom rises above 75°F. From February onwards the temperature generally rises 10°F per mensem until it reaches 115°F to 123°F in June, the night temperature averaging 81°F.

Climate.

The Punjab has two well-defined rainy seasons. The south-west monsoon reaches the Punjab at the end of June, and most parts only get rain about middle of July. Most of the rain falls in the submontane and montane areas, and very little generally falls in the dry South-West tracts. The summer rains generally cease about the middle of September or earlier.

Rainfall.

The North-East depression gives rain from December to middle of March, and is on the whole much better distributed than the South-West supply. The total rainfall in the winter, however, is generally much smaller than in summer. The yearly rainfall decreases rapidly as we pass westwards away from the hills. In the Himalayas it is nowhere less than 36 inches, and in places like Dharmasala may average over 100 inches. The eastern plains from Delhi to Lahore average 24 inches. West of Lahore the rainfall decreases rapidly to 12 inches at Lyallpur, 8 inches at Jhang and 5 or 6 inches at Multan and westwards of Multan. During the summer season heavy cyclonic storms are sometimes experienced with a fall of over 6 inches rainfall in 24 hours causing some damage to crops. Hailstorms do damage occasionally in late summer or in April, but the effect is generally very local. Maps A and B show distribution of summer and winter rainfall.

The soil of the Punjab plains is practically all alluvial or deposited from the rivers. It forms a part of the great Indo-Gangetic plain. In consistency it is generally a sandy loam.

Soil.

Heavy clay is found in wet rice tracts and in a long strip reaching from Gurdaspur to Khanewal along the Ravi. This latter soil is called *bara* or *bari*, and is barren in most cases. In Montgomery District on the Lower Bari Doab Canal, it occupies an area of 10,000 acres *bara* and 75,000 acres *bari* land. Very sandy soils are found in Mianwali and in parts of the Sind Sagar Doab.

Civil administrative arrangements.

The Province is divided into five Divisions, each in charge of a Commissioner. Each Civil Division is, fairly distinct agriculturally (See Chapter II, statement III). There are six Districts in each Division, except Jullundur, which has got only five Districts. Each District is in the charge of a Deputy Commissioner, whose main work is in connection with land revenue collection and settling of revenue disputes. Each District is divided into *Tehsils* each under a *Tehsildar*. The number of *Tehsils* in each District varies from 3 to 5, excepting Simla, which has got only two *Tehsils* and Gurgaon and Multan each of which has got 6 *Tehsils*. A *Tehsil* is divided further into *Zails* each of which has one *Kanungo*, and 20 to 30 *Patwaris*. The *Zaildar*, who is also generally a *Lambardar*, helps in the work of running a *Zail*. A *Patwari* has generally one or two villages in his charge. Each village has one or more (depending upon the size of the village), Headman or *Lambardar*, who is generally the most influential man in the village. The *Lambardar* assists in the collection of revenue and is a semi-official.

There are 202 towns and 35,256 villages in the Punjab. The town possesses distinct urban characteristics and its population is usually not less than 5,000 inhabitants, while the village means a revenue village. Urban and rural population means persons living in towns or villages as above defined. Of the total population 15·3 per cent. is urban as against 13 in 1931, 10.7 in 1921, and 10·1 in 1911. Up to 1921, there was no appreciable increase in the percentage of urban population but since then there has been a substantial increase. There are many reasons for this heavy increase. The most important of them is industrialisation which tends to produce large aggregations. The other reasons are the desire on the part of retired and leisured classes to live in the towns, in the interest of educating their children and for other amenities. Another cause, though a minor one, is the anti money-lending legislation, which has made things so difficult for the rural *bania* that he has realised his outstanding debts as far as he could, and moved to the city to take up some other business. The increased urbanisation is desirable as it is helpful in reducing the heavy pressure on land. The number of villages in a district and its area vary considerably. Leaving out Simla, Jullundur is the smallest District with an area of 1,334 square miles, while Kangra is the biggest with an area of 9,979 square miles.

The number of villages is the smallest in Mianwali—410, though the total area is 5,401 square miles, while Gurdaspur with an area of 1,846 square miles only has got the largest number of villages, *i.e.*, 2,229. The density of population in each district also varies considerably. It is 94 per square mile in Mianwali as against 906 in Amritsar.

Origin of Agricultural Departments in India.

Agricultural Departments in India owe their origin to the Famine Commissions of 1880, 1898, 1901, and the Irrigation Commission of 1903. Of these, the Famine Commission of 1901 was by far the most important, though the necessity for bringing about improvement in agricultural methods and for agricultural research had been emphasised by all these Commissions in order to guard against the disastrous effect of famines. But agricultural research was erratic and lacked continuity and there was little attempt made at building up a scientific department till the beginning of this century when great interest in scientific agriculture was aroused in Great Britain as well as in India.

In pursuance of the recommendations of the Famine Commission of 1901 and the Irrigation Commission of 1903, a Central Agricultural Research Institute and an Agricultural College at Pusa in the Darbhanga District of Bihar was established. To the establishment of this station, Lord Curzon devoted a greater portion of a generous donation of £30,000 which had been given to him by an American gentleman, Mr. Henry Phipps of Chicago. It was also realised at this time that a central research institute could be of only limited utility without the development of scientific agriculture in the Provinces. In 1905, therefore, the Government of India provided a recurring sum of Rs. 20 *lakhs* per annum which was subsequently increased to Rs. 24 *lakhs* in the development of agricultural research, experiment, demonstration, and education in the provinces. The Punjab province also obtained its due share. In pursuance of this scheme, colleges were started or re-organised at Poona, Cawnpore, Nagpur, Lyallpur, Coimbatore and Sabour. The last mentioned college was closed at the end of 1921. A separate Department of agriculture was constituted in most Provinces and scientific staff was appointed.

In the mean-time the Punjab Government opened a 56 acre Experimental Farm at Lyallpur in 1901 which was staffed by Agricultural Assistants, who had been trained at Cawnpore. This farm formed the nucleus of what is now the largest and the most progressive Agricultural College and Research Institute in India. In 1904 the first post of the Deputy Director of Agriculture in the Province was sanctioned and the Economic Botanist for work in U. P. and Punjab was engaged and stationed at Saharanpur. The appointment of a Deputy Director of Agriculture was made in 1905 and he was followed in 1907 by an Economic Botanist and an Agricultural Chemist for research work in the Punjab.

As the time rolled on, new officers were added for general agriculture, research and education, and the progress which has been made during the last 40 years can be seen from the fact that at present there are 26 Imperial and Class I Officers, 89 Provincial Class II Officers, and 1,927 superior subordinate staff. While the research staff is engaged in conducting research on matters connected with crop, soil improvement, insect pests, diseases, etc., it is the duty of the general agricultural staff to show cultivators how to improve their methods of cultivation and to secure better returns from their lands. For District Demonstration and Propaganda, the Province is divided into 8 circles, each in the charge of a Deputy Director of Agriculture. Under him in each District, excepting Simla, an Extra-Assistant Director of Agriculture is posted, who along with Agricultural Assistants (1 to 2 in each *Tehsil*) and *Mukaddams* (2 to 4 in each *Tehsil*), tour in villages, lay out demonstration plots to compare the benefits of new seeds or new methods as against the old practices and customs, give lectures to the cultivators, hold shows and exhibitions on occasions of large gatherings, arrange for supplies of improved seeds, help cultivators to destroy pests and diseases, and advise them in a number of other ways with a view to securing better returns for their labour.

In 1906-07 the gross expenditure on the Agricultural Department was about half a lakh of rupees. In recent years it has increased rather sharply. For the year 1945-46, gross budget provision was Rs. 10,364,700, *i.e.*, over a crore, a sum not hitherto provided in the Agricultural Budget including Game and Fisheries (omitting livestock) of this Province or any other Agricultural Department in India. During the year 1945-46, the Budget Estimate of Receipts was Rs. 5,259,700. Thus the net expenditure on the Agricultural Department was only about Rs. 5,105,000 and averaged about Re. 0-1-4 per acre over the whole area of the Punjab or Re. 0-2-7 over its cultivated area. This expenditure of two-and-a half annas per cultivated acre cannot be considered high for the improvement of the main industry of the Province.

References

(1) Imperial Gazetteer (Punjab).

(2) Note by H. W. Nicholson, Punjab Irrigation Department, on discharges of the Punjab rivers.

(3) Report of the Royal Commission on Indian Agriculture (1928).

(4) Punjab Government Budget (1945-46).

(5) Census of India (1941), part VI, Punjab.

CHAPTER II

AGRICULTURAL STATISTICS

Area and population.

According to 1941 census, the total area of the British Punjab is 99,089 square miles with a population of 28,418,819. As regards size, the Punjab is the third largest Province in India, the first two being Madras (126,166 square miles) and U. P. (106,247 square miles). In population it is the fifth, the first four being Bengal (60 million), U. P. (55 million), Mardas (49 million), and Bihar including Chhota Nagpur (36 million). The density of population in the British Punjab is 287 per square mile as against 248 for the Punjab including Punjab States, 779 in Bengal, 521 in Bihar, 518 in U. P. and 391 in Madras. During the last 30 years there has been a regular increase in the density of population in the Punjab. It was 198 in 1911, 209 in 1921, and 238 in 1931.

The table below shows the classification of the area:—

Classification.	(Average of 5 years' period ending 1943-44).	*Acres.*
Area according to survey		61,001,600
Area according to village papers		60,196,576
Cultivated area	Net area actually sown	28,001,558
	Current fallows	3,639,377
Un-cultivated	Culturable waste other than fallow	13,675,212
	Not available for cultivation	12,914,534
Forests		1,950,690

It will be noticed that the area according to village papers is about 0·8 million acres less than that by professional survey. This difference may be due to the fact that—

(*a*) the survey area is calculated in blocks, while the area according to village papers is obtained from the added totals of field and village areas, and

(*b*) the system of inclusion and exclusion of areas not available for cultivation is not uniform in the two methods.

Of the total area, only about 52 per cent is cultivated, the remaining 48 per cent is either uncultivated or is under forest. Of the uncultivated area a little over half is culturable waste other than fallow. This is lying waste either due to lack of irrigation facilities or for other defects. During the last three decades, there has been considerable change in these figures. The cultivated area increased from about 28 million acres in 1913-14 to 29 million acres in 1916-17, 30 million acres in 1924-25, 31 million acres in 1933-34, and 32 million acres in 1942-43. There has been a corresponding fall in the uncultivated and forest areas. The forest area was 3·3 million acres in 1913-14, 2·2 million acres in 1916-17 and 1·97 million acres in 1931-32. Since then only a slight fall has occurred. A similar decrease occurred in the cultivable waste which was 17 million acres in 1913-14, 16 million acres in 1921-22, about 15 million acres in 1929-30, about 14 million acres in 1938-39, and about 13 million acres in 1943-44. There was a slight increase in the area not available for cultivation. It was 12·3 million acres in 1912-13, 12·6 million acres in 1928-29 and 13 million acres in 1938-39.

Forests.

Forests are a national asset to the country as they are useful in more than one ways and particularly so in the Punjab where the canal irrigation is of vital importance to her agriculture and river supplies which feed the canals are dependent on the steady flow of water from the mountains. The forests not only attract rains, but also act as a sponge in receiving water and releasing it gradually, thus avoiding soil denudation at the foot of hills and reducing damage by floods in the plains during heavy rains.

This is why re-afforestation and preventing of erosion should be a Provincial subject, and subsidized from general revenues. The tendency at present is to put the burden on the impoverished residents in hilly tracts, who are often somewhat harshly treated, and frequently sacrificed in the general interest of the Province. One of our post-war problems is to work out a fair policy in this respect which would command the support and co-operation of local interests and appeal to the sense of justice of the plains population.

The hill forests are a national asset and important both for supply of timber and fuel. In the plains the problem is one of developing "arboriculture" rather than forests. Increase in the fuel supply would release dung for use as manure and thus avoid the waste of valuable plant food through use of dung-cakes as fuel.

Area cropped.

The net area sown in the Punjab in 1943-44 was 28,543,453 acres but the total area of crops sown in that year was 33,002,818 acres. This shows that 4·5 million acres were sown more than once in the year which is generally known as "double cropped." There are great variations in the double-cropped area from year to year. In 1939-40, it was only 4,202,721 acres as against 5,373,599 acres in 1942-43 which was a comparatively favourable year.

Of the total-cropped area about 53 per cent is irrigated and the remaining 47 per cent is unirrigated locally known as *barani*. Of the total irrigated area, 70 per cent is irrigated by Government canals, 3 per cent by private canals, 26 per cent by wells, and 1 per cent by other sources. The area irrigated by tanks is only about 41,000 acres. There are two types of wells—masonry and non-masonry. Out of a total of 354,000 wells, 334,000 were masonry and only 20,000 non-masonry. During the last 20 years there has been an increase in the number of masonry wells from 2·7 *lakhs* to 3·3 *lakhs*, while there was a decrease in the non-masonry wells from 23,000 to 20,000.

Increase in irrigated area.

There has been a considerable increase in the irrigated area. It was about 10 million acres in 1910, 13 million acres in 1920, 15 million acres in 1928-29, 16 million acres in 1937-38, 17 million acres in 1939-40, and 17·6 million acres in 1943-44. This increase in the irrigated area is mostly due to increase in area irrigated by Government canals. The area irrigated by Government canals was only 5 million acres in 1903-04. It increased to 8 million acres in 1916-17, 10 million acres in 1928-29, about 11 million acres in 1936-37 and 12·5 million acres in 1943-44. There has been practically no change in the area irrigated by private canals and other sources. There has been an increase in the area irrigated from wells by about 1 million acres during the last two decades. Development of Punjab agriculture during the last 50 years may, therefore, be taken to be due mainly to the development of the Government canal irrigation.

Proportion of *kharif* and *rabi*.

The table below gives the area sown under *kharif* and *rabi* crops for the each of six years ending 1943-44 :—

		Area in thousand acres.					
		1938-39	1939-40	1940-41	1941-42	1942-43	1943-44
Total *kharif* crops	Irri. ..	6,770	6,838	6,915	6,963	6,747	7,263
	Un-irri.	5,972	6,224	7,421	6,915	8,017	7,236
	Total..	12,742	13,062	14,336	13,878	14,764	14,499
Total *rabi* crops	Irri. ..	10,065	10,209	10,245	10,242	10,113	10,340
	Un-irri.	6,038	6,676	8,221	8,179	10,112	8,164
	Total ..	*16,103*	*16,885*	*19,466*	*19,421*	*20,225*	*18,504*
Total area sown	Irri. ..	16,835	17,047	17,160	17,205	16,860	17,603
	Un-irri.	12,010	12,900	15,642	15,094	18,129	15,400
	Total ..	28,845	29,947	32,802	32,299	34,989	33,003

It will be seen that there are considerable variations in the unirrigated sown area due to wide fluctuations in the amount and distribution of rainfall. It was as low as 12 million acres in 1938-39, a famine year and as high as 18·1 million acres during 1942-43, which is considered to be a very favourable year. In years of good rainfall, irrigation on an extensive scale is not needed, particularly from wells, tanks, etc., and, therefore, the area under irrigation from sources other than Government canals goes down a little, while in years of deficient rainfall it increases because the cultivator, in order to maintain himself, has to resort to all sources of irrigation for raising crops.

The above remarks apply mainly to zones with an annual rainfall above 20 inches. For the whole of the western part of the province comprising important Districts of Lyallpur, Shahpur, Jhang, Multan, Montgomery, Dera Ghazi Khan and Muzaffargarh cultivation depends almost entirely on irrigation.

From the agricultural point of view there are two main seasons in the Punjab—summer and winter. Crops grown in summer are called '*kharif*' and those in the winter season '*rabi*'. The crops grown during autumn are called '*zaid kharif*', such as *toria*, and those grown in spring, *i.e.*, between '*rabi*' and '*kharif*' such as tobacco, are called as '*zaid rabi*.' Of the total area sown, about 14 million acres or 43 per cent is put under *kharif* crops and the rest about 18½ million acres or 57 per cent is under *rabi* crops. The area under *zaid kharif* and *zaid rabi* is not separately recorded. It is included in the *kharif* and *rabi* areas respectively. Half of the total area under *kharif* crops is irrigated and the other half is unirrigated. In good years such as 1942-43, the proportion of unirrigated area increases while in years of poor rainfall, such as 1938-39, it is proportionately less. (See table for *kharif* and *rabi* figures in these two years). It may be noted that both in *kharif* and *rabi* area there is very little variation from year to year in the irrigated areas.

Another interesting thing is that the unirrigated area in *rabi* is only slightly more than unirrigated area in *kharif*, the actual figures being 8·2 million acres and 7·1 million acres respectively; while the irrigated is about 50 per cent more in *rabi* than in *kharif*, the actual figures being 10·2 million and 6·9 million acres respectively. The reason for proportionately large area under irrigated *rabi* crops is that owing to the winter season the crops require less water for maturing, though the quantity of canal water available for irrigation is less than in the *kharif* season. In summer season, though the quantity of canal water available is more, but due to hot season and consequently more loss by evaporation from soil surface and crop transpiration more water is needed by the crops. The canals are in a way machines and the cultivator has adapted his cropping to the machine.

STATEMENT I.

AREA UNDER DIFFERENT CROPS IN THE PUNJAB FOR THE QUINQUENNIUM ENDING 1943-44.

Crop.	Area in 000' acres. Irrigated	*Barani*	Total.	Percent. Irrigated.	Percent of total cropped area.
I.—Cereals and Pulses.					
Wheat	5,827	4,155	9,982	58·4	30·6
Barley	348	460	808	43·1	2·5
Rice	848	187	1,035	81·9	3·2
Mandhal	17	11	28	60·7	0·1
Bajra	678	3,066	3,744	18·1	11·5
Jowar	194	636	830	23·4	2·5
Maize	591	630	1,221	48·4	3·7
Other Cereals	89	86	175	50·9	0·5
Gram	1,112	2,540	3,652	30·4	11·2
Mung Mash	101	345	446	22·6	1·4
Other pulses	166	552	718	23·1	2·2
Total ..	9,971	12,668	22,639	44·0	69·4
II.—Other Food Crops.					
Sugarcane	407	78	485	83·9	1·5
Vegetables (including Potatoes)	148	85	233	63·5	0·7
Fruits	62	34	96	64·6	0·3
Miscellaneous	58	50	108	53·7	0·3
Total ..	675	247	922	73·2	2·8
III.—Oilseeds.					
Taramira	52	376	428	12·1	1·3
Toria	287	22	309	92·9	1·0
Sarshaf	64	176	240	26·7	0·7
Mustard	5½	3½	9	61·1	..
Linseed	20	13	33	60·6	0·1
Til	21	63	84	25·0	0·3
Groundnut	..	40	40	..	0·1
Castor and Others	2	1	3	66·7	..
Total ..	451½	694½	1,146	39·4	3·5
IV.—Cotton.					
Desi	900	144	1,044	86·2	3·2
American	1,549	14	1,563	99·1	4·8
Total ..	2,449	158	2,607	93·9	8·0
V.—Fodders	3,460	1,612	5,072	68·2	15·6
VI.—Other Crops.					
Tobacco	60	1	61	98·3	0·2
Bhang and other drugs ..	½	½	1	50·0	..
Condiments and spices ..	64	4	68	94·1	0·2
Hemp and other fibres ..	22	25	47	46·8	0·1
Indigo and other dyes ..	11	10	21	52·4	0·1
Poppy	1	..	1	100·0	0·1
Tea	4	5	9	44.4	
Miscellaneous non-food crops ..	6	8	14	42·9	
Total	168½	53½	222	75·9	0·7
Grand Total ..	17,175	15,433	32,608	52·7	100·0
Kharif ..	6,945	7,163	14,108	49·2	43·3
Rabi ..	10,230	8,270	18,500	55·3	56·7

So far only sown area has been discussed. Owing to deficient rainfall a considerable part of the sown area fails to mature. The failed area is more in years of deficient rainfall, and less in favourable years, for obvious reasons. The statement below shows the failed and matured area for each of the six years ending 1943-44 :

Variation in total cropping.

STATEMENT II.

Particulars.		*Area in thousand acres.*					
		1938-39	1939-40	1940-41	1941-42	1942-43	1943-44
Total area of crops failed.	Irri. ..	1,286	839	856	599	685	645
	Un-irri.	4,990	4,799	4,372	4,435	2,610	3,142
	Total..	6,276	5,638	5,228	5,034	3,295	3,787
Total area of crops matured.	Irri. ..	15,549	16,208	16,305	16,607	16,174	16,958
	Un-irri.	7,021	8,101	11,269	10,659	15,519	12,258
	Total..	22,570	24,309	27,574	27,266	31,693	29,216

It will be observed that the area of crops failed was only 3·3 million acres in 1942-43 a favourable year, as against 6·3 million acres in 1938-39 a famine year. Most of the failed area was unirrigated.

The actual area under various crops separately for irrigated and unirrigated along with the percentage of each crop to the total cropped area for the five years' period ending 1943-44 is given in the accompanying table (see page 13.)

It will be observed that 69·4 per cent. of the cropped area is under foodgrains—cereals and pulses—15·6 per cent. under fodders which are fed to livestock, 2·8 per cent. under other food crops as sugarcane, vegetables and fruits, thus making a total of 87·8 per cent. under food and fodder crops. Of the remaining 12·2 per cent. cotton forms 8 per cent., oil seeds 3·5 per cent., and other crops like tobacco, condiments, poppy, etc., 0·7 per cent.

As the cotton crop is two third oil seed and one third fibre, it constitutes our most important oil seed, and contributes with other oil seeds valuable cattle and human food. If we take the contribution of the cotton crop into the picture we may put the oil seeds area as 8·5 per cent. i.e., adding 5 per cent. from cotton. This leaves only 37 per cent of the cropped area devoted to purposes other than food for man or beast.

Crops.

Wheat is the most important crop occupying about 31 per cent. of the total cropped area. About 58 per cent of the wheat area is irrigated. *Bajra* and gram are the next two important crops each occupying about 11 per cent of the cropped area. In case of gram 30 per cent is irrigate as against only 18 per cent for *bajra*. The other foodgrains are of comparatively minor importance, each occupying about 1 to 4 per cent of the cropped area.

Sugarcane is important in the other food crops occupying 1·5 per cent of the cropped area. About 84 per cent of it is irrigated. Vegetables and fruits occupy only about 0·7 and 0·3 per cent respectively.

Oilseeds excluding cotton account for only 3·5 per cent of the cropped area. About 40 per cent of this is irrigated. The important oilseeds are *taramira* occupying 1·3 per cent, *toria* 1·0 per cent, and *sarson* 0·7 per cent. *Toria* is mostly irrigated—93 per cent while *taramira* is mostly *barani*, only 12 per cent being irrigated. In the case of *sarson* nearly 3/4th is *barani*.

Cotton is an important commercial crop in the Punjab occupying 8 per cent of the cropped area. It is mostly an irrigated crop—94 per cent irrigated. There are two varieties of cotton—*desi* and American. The former occupies 3·2 per cent of the area as against 4·8 per cent for the latter. Both the varieties of cotton are mostly irrigated, the percentage of irrigated area are being 99 per-cent in case of American and 86 per cent in the case of *desi*. The comparative position of cotton has been considerably affected by "Grow More Food" campaign during the last three years of war. A part of the area under *desi* cotton has given place to food grains owing to low prices of *desi* cotton, on account of heavy accumulation of stocks caused by war conditions, and comparatively higher prices of foodgrains. During the last three years, the area under *desi* cotton has gone down to about ½ of the pre-war level. From production standpoint the Punjab is the premier cotton province.

STATEMENT III.

STATISTICS BY DIVISIONS FOR THE QUINQUENNIUM ENDING 1943-44.

AREA IN ACRES.

Division.	District.	Population 1941. '000.	*Uncultivated.* Culturable waste other than fallow.	*Uncultivated.* Not available for cultivation	Forests.	*Cultivated.* Net area sown.	*Cultivated.* Current fallow.	Area irrigated.	*Main Crops.* Crops.	*Main Crops.* Acres.
Ambala	Hissar ..	4,695	1,524,784	1,023,719	61,940	5,826,780	1,040,934	1,438,455	*Bajra* ..	2,058,514
	Rohtak ..								Gram ..	1,104,256
	Gurgaon ..								Wheat ..	766,903
	Karnal ..								*Jowar* ..	416,390
	Ambala ..								Barley ..	311,163
	Simla ..								Rapeseeds	235,568
									Cotton ..	231,899
									Maize ..	156,304
Jullundur	Kangra ..	5,438	955,197	4,822,674	699,611	4,468,883	458,930	2,450,997	Wheat ..	1,684,320
	Hoshiarpur ..								Gram ..	890,541
	Jullundur ..								Maize ..	540,851
	Ludhiana ..								Pulses ..	258,378
	Ferozepur ..								*Bajra* ..	239,036
									Cotton ..	213,977
									Rice ..	177,798
									Barley ..	170,397

Lahore	Lahore, Amritsar, Gurdaspur, Sialkot, Gujranwala, Sheikhupura	7,218	1,232,051	1,032,282	37,317	5,105,468	386,597	4,403,890	Wheat	2,232,483
									Rice	540,546
									Gram	493,053
									Cotton	463,262
									Bajra	305,262
									Maize	268,685
									Rapeseeds	217,935
									Sugarcane	187,139
Rawalpindi	Gujrat, Shahpur, Jhelum, Rawalpindi, Attock, Mianwali	4,701	2,958,056	3,542,679	1,043,249	5,578,441	605,473	1,624,742	Wheat	2,448,779
									Bajra	848,216
									Gram	715,136
									Cotton	300,924
									Pulses	258,100
									Rapeseeds	198,392
									Jowar	144,163
									Maize	126,692
Multan	Montgomery, Lyallpur, Jhang, Multan, Muzaffargarh, Dera Ghazi Khan	6,366	7,005,124	2,493,180	108,573	7,021,986	1,147,443	6,997,758	Wheat	2,849,542
									Cotton	1,396,510
									Gram	448,912
									Bajra	292,949
									Pulses	271,087
									Jowar	245,489
									Rapeseeds	207,108
									Rice	160,228
	Total	28,418	13,675,212	12,914,534	1,950,690	28,001,558	3,639,377	16,915,842		

Fodder crops are quite important in this province, occupying about 5 million acres or 15·6 per cent. of the cropped area. This is about 48 per cent. of the total area under fodder crops in the whole of British India. The area in Bombay is about 2½ million acres, in U. P. 1½ million acres and all other Provinces account for only about 1½ million acres. The higher percentage of fodder crops in the Punjab is perhaps due to a better feeding on account of better type of livestock and low quality of grazing areas in the plains as a result of severe climate. This matter appears to require further study. About 68 per cent. of the area under fodders is irrigated.

Among other crops, tobacco and condiments and spices occupy 0·2 per cent. each.

Agricultural statistics by divisions.

The accompanying Statement III (page 16) gives the important agricultural statistics along with the main crops grown in the various Civil Divisions of the Punjab.

Population.

It will be observed that Lahore Division has got the highest population, closely followed by Multan. The other three Divisions have got comparatively less population.

Net area sown.

In this respect, Multan with 7 million acres is at the top, followed by Ambala, Rawalpindi and Lahore Divisions in the order of importance. In the Jullundur Division, the net area sown is the lowest, being only 4·5 million acres.

Current fallows.

In this respect as well, Multan heads the list. This may be due to seasonal canals in parts of this Division as well as due to scarcity of irrigation supplies in some of the perennial canals. Ambala comes next with 1 million acres. This is due to scarcity of rainfall and lack of adequate means of irrigation. In Rawalpindi Division the area under current fallow is only 6 *lakh* acres. Most of the area in this Division is *barani*, but winter rainfall being better in this Division than in the rest of the Punjab, the area under current fallow is less. In Jullundur and Lahore the current fallow area is about 4½ *lakh* and 3¾ *lakh* acres respectively. As regards percentage of the current fallow to total cultivated area, Ambala comes at the top with about 15 per cent, closely followed by Multan with 14 per cent, Rawalpindi 10 per cent, Jullundur 9 per cent, and Lahore 7 per cent.

Irrigated area.

With respect to irrigation, Multan has practically got the whole of the net area sown as irrigated, closely followed by Lahore with about 86 per cent sown area under irrigation. In Rawalpindi and Ambala Divisions, the irrigated area forms only 30 per cent and 24 per cent respectively of the total area sown. In Jullundur the irrigated area is about 55 per cent of the sown area.

Forests.

With regard to forests, Rawalpindi is at the top with 1 million acres, followed by Jullundur with 7 *lakh* acres and Multan 1 *lakh* acres. Lahore is the worst with only 37,000 acres. In Ambala the area is only 62,000 acres.

Culturable waste.

Multan has got the largest area under culturable waste, *i.e.*, 7 million acres, which is just equal to the net area sown in this Division. Next comes Rawalpindi with about 3 million acres, followed by Ambala and Lahore with 1·5 million acres and 1·2 million acres respectively. In Jullundur the cultivable waste is the lowest, *viz.*, only 9½ *lakh* acres.

Not available for cultivation.

As regards unculturable land, Jullundur comes at the top with 4·8 million acres, followed by *Rawalpindi with 3·5 million acres, Multan* with 2·5 million acres and Lahore and Ambala with 1 million acre each.

Crops.

Wheat is by far the most important crop in all the Divisions, except Ambala, where *bajra* and gram are much more important than wheat.

Gram comes second in Ambala and Jullundur Divisions and third *in the other* three Divisions.

Bajra is the next important crop occupying first position in the Ambala Division and second in Rawalpindi. It is comparatively of lesser importance in other Divisions.

Rice is important in the Lahore Division occupying the second position. It is also grown in Jullundur and Multan Divisions to some extent.

Cotton is an important crop of the Multan Division where it is next to wheat. It is also important in Lahore and Rawalpindi Divisions where it occupies fourth position. In Ambala and Jullundur Divisions also, it is quite an important crop.

Pulses are important in Multan, Rawalpindi and Jullundur Divisions.

Maize is an important crop of the Jullundur Division occupying third position. Next comes Lahore. It is also grown in Ambala and Rawalpindi to a fair extent. Multan Division does not grow much maize.

Rapeseeds are important in Ambala, Multan, Lahore and Rawalpindi Divisions. Jullundur is not of much importance for this crop.

Sugarcane is mostly concentrated in the Lahore Division which grows about 39 per cent of total area under this crop. Next comes Jullundur with 21 per cent followed by Ambala 18 per cent and Multan 17 per cent. Rawalpindi Division does not grow much cane.

Jowar is important in the Ambala and Multan Divisions. It is also grown to a fair extent in Rawalpindi. It is grown mainly as a fodder.

Land Revenue and Occupiers' Rates.

The gross revenue from land and irrigation in 1943-44 was about 9·9 *crores* of rupees. Of this 3·57 *crores* of rupees or 36 per cent was from the land revenue and Rs. 6·33 *crores* or 64 per cent from irrigation. The incidence of land revenue per acre on the total area fully assessed in 1942-43 was Rs. 1-9-9 and on the cultivated area Rs. 1-15-9. According to sales of land, where the right of ownership was transferred permanently, the price per cultivated acre for the year 1942-43 was Rs. 556. This was 313 times the land revenue for the year. The corresponding figure was 241 in 1934-35, 300 in 1924-25 and 134 in 1914-15. The incidence of land revenue varies a good deal from district to district, as shown in the following figures for some of the districts for the year 1939-40:

District.	Incidence of land revenue on the fully assessed area per acre. For total area.	For cultivated area.
	Rs. a. p.	Rs. a. p.
Mianwali	0 5 9	0 7 7
Hissar	0 7 3	0 12 6
Attock	0 12 6	0 13 6
Ferozepore	0 15 10	1 3 4
Jehlum	1 0 10	1 4 9
Muzaffargarh	0 5 4	1 5 8
Dera Ghazi Khan	0 15 11	1 6 0
Rawalpindi	1 3 1	1 9 5
Ambala	1 15 7	2 1 8
Ludhiana	1 14 2	2 6 7
Jullundur	2 10 3	3 5 9

The land revenue in the Canal Colonies varies from Rs. 2-4 for Class VI of land to Rs. 12 per acre for the town *lands according to the quality of the land. In the* last 10 years a system of correlating revenue collections with prices has been introduced in Lyallpur and Montgomery. Before this system was enforced, the practice was to take the average of the prices of each crop over a period of years to represent roughly the price that would prevail until the next settlement. No change was then made in the land revenue rates during the period of settlement, as a result of fluctuations in prices. This system works satisfactorily so long as voilent changes in prices do not occur. In the case of higher prices the system worked in favour of the revenue payer, because according to the law, Government could not increase the Land Revenue during the currency of a Settlement. In the case of lower prices the land revenue payer found it difficult to meet his dues, especially in those Districts which had been reassessed during the boom years. In such cases Government had to come to their help by giving liberal relief at each harvest in the form of special *remissions. It was, therefore, considered expedient* in fairness to the revenue payer, to devise means of permanent relief. After very careful consideration the

Punjab Government decided to adopt a system of assessment which will make the demand, each harvest, dependent on prices. This system was introduced in the re-assessment of the Lower Bari Doab Canal Colony in 1933-34 and later in the Lower Chenab Canal Colony in 1936-37. Its chief features are—

(1) The commutation prices were worked out on the average of 20 years, in accordance with the Revenue Law.

(2) Average revenue rates are worked out according to those prices to determine the average rate for the assessment circle as a whole.

(3) The revenue rate, as finally announced, represents the maxima, which the Government can take in any circumstances during the period of 40 years.

(4) Government will not take these maxima rates unless the prices reach the level given in the schedule.

(5) In case of prices being higher than those given in the Schedule the revenue payer will be given the full advantage of the excess.

(6) In case of lower prices remission proportionate to the difference will be given in the following year.

This system was a revolutionary change in the method of assessment, and was considered to be in the interests of the land revenue payer and of Government.

Procedure.

The prices were collected in *annas* per *maund* from leading firms in certain *mandis* of the tract as follows:

Cotton	..	November to February.
Gur	..	December to March.
Toria	..	January to February.
Wheat	..	May 15 to September 15.
Gram	..	April 15 to August 15.

The crops taken into consideration cover about 75 per cent. of the total. From the average daily prices in *annas per maund* will be deducted transport and marketing charges, so that the average price will represent the average price in the village. In calculating the remission the three factors are considered—

(*a*) The percentage of the total matured area under each important crop.

(*b*) Average yield per acre in *maunds*, of each crop.

(*c*) The commutation price assumed for each of those crops in *annas* per *maund*.

By multiplying these figures an index figure is obtained. Supposing the standard index figure at the time of settlement was one thousand and the index figure according to the new prices is 600, the remission given will be 40 per cent. Each year a new index figure will be calculated and the amount of remission will thus depend on the level of prices during the previous year. The actual standard index figure was 73,760 as against 33,366 for 1934-35 worked out on the prices current in 1933-34, *i.e.*, roughly 45 per cent. of the standard index figure. This means that according to Sliding Scale System, remission of 55 per cent. would be given in 1934-35.

This system has been vigorously criticised by economists, who contend that remission given in a particular harvest on the basis of prices alone, does not take into account all the reduced net assets of the landlord, because costs of cultivation, which are not quite elastic are not reduced in the same proportion as that represented by the difference between the current prices and the commutation prices. This criticism has some force. At least one item of cost that is the *abiana* charge remains constant. It may be said, however, that the Sliding Scale System is not an exact mathematical proposition. All that it postulates is the introduction of a degree of flexibility in the rigidity of the old revenue system. The actual operation of this scale has established its popularity with the zemindars, who secured substantial relief. The system could, perhaps, be improved by calculating the demand on the basis of current prices, say the average of the last five years, and then scaling it up and down, according to the rise and fall in prices. But it would have been very difficult to make the cultivator agree to pay in excess of the demand announced at settlement. A demand that is liable to increase indefinitely is always less acceptable than a definite commitment. This is the main advantage of this system. It may also be pointed out that as remission percentage is dependent on prices of previous year, some hardship may be felt in years of sudden fall of prices. This can, however, be overcome by delaying the dates of the payment of land revenue in the two harvests by about a month, as it will then be possible to utilize the prices of the same year for working out the remission.

According to the Sliding Scale System the incidence of the demand per matured acre and per cultivated acre in Lyallpur District is as follows:

Assessment circle.	Circle rate per matured acre.	Circle rate per cultivated acre.
	Rs. a. p.	Rs. a. p.
Jaranwala	6 3 0	6 7 0
Lyallpur	6 2 8	6 6 1
Samundri	5 12 10	5 14 10
Toba Tek Singh..	5 3 4	5 1 5
New extension	4 12 5	4 6 4
Rakh Branch colony circle ..	5 7 7	5 9 3

Cesses..	Local rate for District Board ..	12½ per cent on Land Revenue demand.
	Lambardari fee ..	5 per cent on Land Revenue demand.

The land revenue per acre on Sliding Scale basis in the Lyallpur District according to class of land is as follows :—

		Rs. a. p.
1.	Town lands (*a*)	12 0 0
2.	Town land (*b*)	9 0 0
3.	Class I	7 8 0
4.	Class II	6 12 0
5.	Class III (*a*)	6 0 0
6.	Class III (*b*)	5 8 0
7.	Class IV (*a*)	4 12 0
8.	Class IV (*b*)	4 4 0
9.	Class V (*a*)	3 8 0
10.	Class V (*b*)	3 0 0
11.	Class VI	2 4 0

Half rates are allowed for *nehri* lift irrigation.

	Rs.	a.	p.
Chahi	1	4	0
Sailabi	1	0	0
Barani and *Abi*	0	12	0

As the assessment is on the matured area, *kharaba* is necessary. The *kharaba* is given if the crop is less than four *annas* of the normal.

The net revenue direct receipts earned by the productive irrigation works during the year 1942-43 amounted to Rs. 3,29,86,540. After deducting from this the interest charges for the year amounting to Rs 1,43,67,283 the net profit was Rs. 1,86,19,257 or 4·78 per cent on the capital outlay of Rs. 38,99,12,893, as against a net profit of 4·44 per cent. on the capital outlay in the preceding year. There are, however, some indirect receipts in the form of a portion of land revenue due to canal irrigation. If these were included the net profit in the year 1942-43 amounted to Rs. 5,16,02,029 or 13·23 per cent. on the capital outlay as compared with 11.27 per cent. in 1941-42.

The water rates of various crops commonly known as occupiers' rates, vary slightly from canal to canal. The rates on the Lower Chenab Canal are as shown below:

Class. *Crop.*	RATE PER ACRE.					
	Flow.			*Lift.*		
	Rs.	a.	p.	Rs.	a.	p.
I.—Sugarcane (except *kharif* channels)	11	0	0	5	6	0
II.—Sugarcane on *kharif* channels	9	0	0	4	8	0
III.—Water nuts	7	8	0	3	12	0
III-A.—Rice	6	8	0	3	4	0
IV.—Indigo and other dyes, tobacco, poppy, spices and drugs	6	4	0	3	2	0
IV-A.—Cotton	5	4	0	2	10	0
V.—Gardens, orchards and vegetables, except turnips (Garden and orchards per half year, the rest per crop)	5	8	0	2	12	0
VI.—Deleted	..			..		
VI-A.—Wheat, barley and oats (except on *kharif* channels)	4	4	0	2	2	0
VII.—Melons, fibres (other than cotton), and all crops not otherwise specified	4	12	0	2	6	0

Class. Crop.	Rate per acre. Flow. Rs. a. p.	Rate per acre. Lift. Rs. a. p.
VII-A.—Maize	4 0 0	2 0 0
VIII.—*Oilseeds* (except *rabi* oilseeds on *kharif* channels)	4 4 0	2 2 0
IX.—All *rabi* crops on *kharif* channels (including gardens, orchards, vegetables and fodders).	2 0 0	1 0 0
IX-A.—Deleted	..	..
X.—*Bajra*, gram, *masur* and pulses	3 4 0	1 10 0
XI.—*Jowar*, *cheena*, grass which has received 2 or more waterings and all fodder crops including turnips	2 8 0	1 4 0
XI-A.—Paddock areas as sanctioned by Local Government	3 0 0	1 8 0
XII (*a*) Watering for ploughing not followed by a crop in the same or succeeding harvest ..	1 0 0	0 8 0
(*c*) Village and District Board plantations :—		
(*i*) Any number of waterings in *kharif* ..	1 0 0	0 8 0
(*ii*) One watering in *rabi*	1 0 0	0 8 0
(*iii*) Two or more waterings in *rabi* ..	2 0 0	1 0 0
(*d*) Grass—a single watering in *kharif* or *rabi* ..	1 0 0	0 8 0

Note.—Grass given two or more waterings falls under Class II. Hemp, indigo, *guara*, and *janter* ploughed in as green manure before 15th September are not assessed to watering.

For other canals, the Administration Reports of the Irrigation Department may be consulted.

Draft cattle.

According to the 1940 census, there were 4·4 million working bullocks and male buffaloes in the Punjab. The area sown during that year was about 30 million acres. This comes to about 14 acres per pair of plough cattle.

The use of camel for agricultural work is becoming quite popular, particularly for the working of persian wheels in some Districts, such as Ludhiana, Ferozepur, Rohtak, etc. The camel is cheaper to maintain and has the advantage of not requiring any driver when working the persian wheel.

The male buffaloes are mainly used as draft animals either in the rice tracts, or for cart work in the cities.

Comparison with Great Britain.

The British Punjab is more or less of the same size as Great Britain (England, Wales and Scotland). It will, therefore, be interesting to compare the agricultural statistics of the two. Statistics about the Punjab have been given on page 8 those for Great Britain are given below:—

Year			Total area	Crops and grass.	Permanent grass.	Arable land.
				(Area in '000	acres).	
1917-18	..	..	56,207	31,958	17,251	14,607
1936-37	..	..	..	29,100	17,335	11,765
1944-45	..	..	..	31,067	11,698	19,369

It will be seen that the total area of Great Britain is similar to that of the British Punjab, being about only 4 million acres less. Of the area returned as culturable in Great Britain, exclusive of 16 to 17 million acres under rough grazing, more than half is normally under permanent grass. In 1944, the area under permanent grass, however, formed only 38 per cent. of the total area under crops and grass, the decrease being due to increase in the arable land by about 7 million acres from 1939 to 1944, as a result of "Dig for Victory" Campaign. Of the total area under arable land in Great Britain in 1944, wheat occupied about 3½ million acres, oats 3½ million acres, barley 2 million acres, and potatoes about 1½ million acres, as compared to 10 million acres of wheat, 800 thousand acres of barley, about 1 million acre of rice, 3¾ million acres of *bajra*, 1¼ million acres of maize, 3½ million acres of gram in the Punjab.

In the livestock the main difference relates to horses, of which there are about 1 million in Great Britain as compared to about 339,000 in the Punjab. There are also about 20 million sheep, 8 million cattle, and 4 million pigs as compared to over 5¾ million sheep, 3½ million goats, and 15½ million cattle in this province. Besides, there are about 640,000 donkeys and 276,000 camels in this Province.

The capital required to farm in Great Britain is much higher than it is in the Punjab. A rough estimate for normal times gives the capital required per acre in Great Britain as £15 or rupees two hundred per acre, whereas in the Punjab the capital required is about 30 rupees an acre at the most. Artificial manures are also extensively used in Britian for crops and scarcely used at all in the Punjab. The main reason is that the value of increase obtained is higher there owing to the higher prices of agricultural produce. Besides, the manures are cheaper there than in India. It is expected, however, that the use of fertilisers will increase in India during the postwar period, as it is proposed to manufacture in India 3½ *lakh* tons of ammonium sulphate per annum near Dhanbad (Behar).

References

(1) Census of India (1941), part I—India.
(2) Census of India (1941), part VI—Punjab.
(3) Agricultural Statistics of India (Punjab)—1938-39 to 1943-44.
(4) Reports on the "Season and Crops" of the Punjab —1939-40 to 1943-44.
(5) Land Revenue Administration Reports.
(6) Administration Report of the P. W. D. (Irrigation Branch), Punjab—1941-42.
(7) Livestock Census (Punjab)—1940.
(8) Agricultural Statistics of Great Britain "The Economist"—October 14, 1944.
(9) International Year Book of Agricultural Statistics —1937-38.
(10) Journal of the Royal Society of England—Vol. 78, 1917.
(11) Report, Fertilizer Commission—1944.

CHAPTER III

PHYSIOLOGY OF PLANTS

Introductory.

The farmer's method of production is by the growing of certain plants, parts of which, such as fruit, stem, leaf or root, as the case may be, represent his saleable commodity. The rearing and maintaining or fattening of animals and poultry is another part of his business, but this aspect is of comparatively minor importance in most parts of the Punjab. Animal husbandry itself represents but an elaboration of some of the farm products. The growing of plants of some sort is, therefore, the most essential part of agriculture; hence some knowledge of the requirements and life processes of plants is an essential part of agricultural science.

Essential parts of plants.*

The parts of a plant which are essential to its life are the roots, stems and leaves. The most important function of the roots is the absorption of water and certain food substances from the soil. This water is conducted through the stems into the leaves, where most of it is transpired into the air.

Absorption of water and salts from the soil.

The roots take water and dissolved food through the root hairs. The latter are unicellular structures found just behind the growing tips of the finest rootlets. They can be seen on the roots of seedlings germinated on moist blotting paper or loose sand. If a plant is pulled up by the roots from the soil, the root-hairs, being fragile, are destroyed, but they can be seen by the naked eye if the surrounding earth is washed away carefully. The root-hairs are closed elongated tubes; water and food pass in through the walls by a process known as "osmosis." This process may be illustrated by the following experiment:—

Take an egg and remove the outer hard shell, leaving

* "Feeding of Crops and Stock"—Hall (published by John Murray, London, pp. 1—50).
"Agricultural Botany"—Percival (published by Duckworth, London, pp. 177—240).
"Strasburger's Botany" —(published by Macmillan, London section, II, pp. 171—323).

the inner skin or membrane, which encloses the yolk and white, intact. This can easily be done if the egg is put in a weak acid, *e.g.*, vinegar or hydrochloric acid for some time beforehand. Now place the soft egg in a strong solution of common salt. This will cause it to shrink, but on being taken out and put in pure water it again expands. The shrinking or swelling was due to water passing out or into the egg according as to whether the solution in contact with it was stronger or weaker than that in the egg itself. A root-hair acts exactly in a similar manner. The solution of cell-sap in the root-hair being more concentrated than soil water, the latter flows into the root-hair. As the root-hairs are in contact with neighbournig cells of the root, the process is continued. The solution from the root-hair passes to neighbouring cells, which have more concentrated solution in them, and hence the process is continuous. If the root-hairs were not in contact with other cells, the continued passage of soil solution into them would dilute the cell-sap until it was of the same concentration as soil water when further movement would cease. Should the soil solution become more concentrated than that of the cell-sap, the latter would shrink and the plants wither. This is the explanation of what happens in *kallar* or salty soils, and is also the reason why in such soils more frequent waterings are necessary to keep the concentration of the soil solution down.

Protoplasm and root-hair cell.

The wall of the cell of the root-hair is lined with a *living substance called "protoplasm"*. This substance further affects the process of absorption in the root-hair as compared to the egg membrane, and seems to exert a selective action so that the amount of the different substances absorbed is not in the same proportion as they exist in the soil solution.

Necessity for plant food to be in solution.

The root-hairs can only absorb substances already in solution in the soil water. This fact is of great importance, and, as will be seen later, underlies much of our agricultural practice. Solid food can only be taken in a soluble state.

The essential chemical elements which the plant obtains from the soil are nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, hydrogen and oxygen. Others not essential for healthy growth, but still absorbed in considerable quantities, and probably useful, are silicon and chlorine. Of the nine essential elements nitrogen and to a less extent phosphorus and potassium, are most important in that considerable quantities are taken, and the supply of these is apt to be short in the soil. Practically all soils contain sufficient of the other essential elements. These three elements are the only ones it is necessary to add in manures, though lime is sometimes indirectly useful. The relative importance of nitrogen, phosphorus and potassium can be demonstrated by growing seedlings in solution, from which one or other of them is lacking. For such an experiment the water and salts *must* be *pure*. *Instructions for preparation* of water cultures of this kind can be had in most Agricultural Chemistry Text Books.

Chemical elements in plant food.

The percentage of the food substances actually dissolved in the soil water is small, so that plants have to absorb large quantities of water. Water moves downwards in the soil fairly rapidly by gravity, but the upward movement by surface tension is comparatively slow. The roots can only take water in contact with them, and hence the deeper and more spreading they are, the larger the mass of water they are in contact with. This partly explains the benefit of delaying the first watering after sowing so as to encourage the roots to go down. Further, one can see there is no advantage in having more than a certain number of plants on the ground, *i.e.*, sufficient for the roots to make full use of the soil.

Roots must feed over a large area.

As pointed out, plant food in the soil can only be absorbed if in solution. Nitrogen and phosphorus can only be absorbed in the form of soluble salts as nitrates and phosphates of potassium, sodium or calcium. Potash may apparently be absorbed in the form of any soluble salts.

Form in which plants take nitrogen, etc.

The very dilute solution of salts in soil water is thus absorbed by the root-hairs by "osmosis" controlled by the living matter (protoplasm) in the cells. By a similar process it passes on to adjoining cells of the root until it reaches the woody part of the root. This woody part consists of long tubular vessels. Apart from its function of giving mechanical support, its main purpose is for the conduct of the solution absorbed by the roots up to the leaves of the plant. The mechanism of this passage is not understood, and still awaits a scientific explanation. In the case of some tropical trees the water is thus raised two or three hundred feet. There is no doubt the solution is carried up, as can be proved by simple experiments.*

Vascular tissue.

Around the wood in such plants as cotton is another structure similar to above called "bast". Its function is to conduct food material manufactured in the leaves to all other parts of the plant where growth is proceeding, or where food is being stored.

Bast.

The whole of the carbon which forms the food of the plant is manufactured into compounds soluble and otherwise in the leaves. The latter possess veins which are visible in most leaves. These veins consist of wood and bast cells which connect through the leaf-stalk with the wood and bast cells of the stem. The raw materials, water and salts, reach the leaf through the wood cells, and the manufactured material passes where required through the bast cells.

Structure of the leaves.

The leaf has a further structure called "stomata," which communicate with the air and through which the plant obtains oxygen and carbon dioxide. This latter substance, though present in the air to the extent of four parts in ten thousand only, is practically the sole source of carbon for the plant.

Stomata.

The main function of the leaves is assimilation of carbon dioxide, its breaking up and elaboration into compounds suitable for the building of the plant. This process of assimilation is carried on by

Assimilation.

*See Percival's "Agricultural Botany," page 190.

the green matter in the leaves, and can only take place in presence of light. All green parts of plants have this power, which is not possessed by animals, or even by many plants, *e.g.*, mushrooms and most fungoid pests such as "broom-rape" of tobacco. If it were not for this power possessed by the green matter (chlorophyll) of plants, all life would cease in a comparatively short time. The function is, therefore, a very vital and important one.

Food manufactured in the leaves.

The foods manufactured in the leaves are of two classes, *viz.* (*a*) carbohydrates and (*b*) proteins. The former consist of carbon, hydrogen and oxygen, *e.g.*, sugar and starch. The green colouring matter in the leaves has the power under the influence of sunlight of combining water (consisting of hydrogen and oxygen) with carbon dioxide gas to form carbohydrates with the liberation of some of the oxygen. The energy required for this is obtained from sunlight. If two seedlings are grown under exactly similar conditions except that one is in darkness and the other in the light, it will be seen that the former develops no green matter, and growth ceases as soon as the food material in the seed is exhausted. The formation of starch in the leaves and the necessity of light and air for this purpose can be shown by simple experiments.*

Proteins.

Proteins are a class of compounds consisting essentially of carbon, oxygen, hydrogen and nitrogen together with small quantities of sulphur and phosphorus. They are the most important substances in the composition of animals and plants. The flesh and blood of animals and the protoplasm of plants consist mainly of proteins. Very little is known of the manner or place of their formation. It is believed that the early stages of their formation take place in the leaves by a combination of carbohydrates and the nitrates and mineral salts absorbed from the soil. The later stages would appear to occur in all living cells of the plant. It seems that potash and calcium play an essential part in the process by some form of catalytic action, though these substances form no part of the finished product.

* See Hall's "Feeding of Crops and Stock."

The food manufactured in the leaves is either passed through the bast to parts of the plant which are growing, and thus helps to form new cells, or it may be stored in various parts of the plant. Examples of such storage are seen in the case of fruits or seeds of all plants and in the swollen stems or roots of such plants, as turnips, carrots, bulbs of onion, or tubers of potatoes or sweet potatoes.

Storage of food.

As pointed out above, the mineral solution taken up by the roots is very dilute. It is concentrated in the plant by the evaporation which takes place through the stomata of the leaves. The latter are mainly found on the lower sides of the leaf. The plant thus transpires several hundred pounds of water for each pound of dry matter produced. The transpiration is regulated by the stomata, which close if the transpiration is greater than the supply from the roots. Some plants have special means of checking transpiration, *e.g.*, small hairs on the leaf as in the case of gram and lentils. *Wan* (*Salvadora oleoides*), which grows in dry desert land, has very thick small leaves, and *karir* (*Capparis aphylla*) is a desert plant still further adapted for minimum transpiration. Both the above trees are common in dry unirrigated tracts in the Punjab plains. Some trees check transpiration by casting their leaves. In the warm summer season plants during the middle of the day often assume a wilted appearance, even though the soil be thoroughly moist, owing to the roots not being able to take up water as fast as it is transpired. Such temporary wilting will not cause leaves to drop. If the soil is dry, however, the plant may drop some leaves to save itself. After severe frost also the roots may be unable to act until the ground has thawed, while the upper air may be warm and transpiration proceeding. Normally, the leaves transpire as much as the roots absorb less the quantity retained by the growing plant, which is considerable, and varies from 80 to 90 per cent. or more of its green weight.

Transpiration.

Breathing is as necessary to plants as to animals, though in the former the process is masked during daylight by the splitting up of carbon dioxide gas and freeing of oxygen. At night, however, only

Respiration.

breathing can take place. If we take a water weed and put it in a test tube full of water, and invert the latter over a basin of water in daylight, we find bubbles soon collect at the top of the tube. This gas will cause a glowing taper to burst into flame, and is mostly oxygen. The carbonic acid gas taken from the water has been split up in the formation of carbohydrates by the plant and some oxygen set free. If the experiment is repeated in the dark, gas collects slowly, and on testing will be found to turn lime water milky, and is in fact mainly carbon dioxide.

Respiration in plants takes place all over the growing parts, including the roots. In the latter the "root-hairs" and growing tips of roots only take in air, and hence for healthy growth the roots must be in aerated soil. Fortunately very little air is required, and sufficient is present in all normal soils. When water stagnates in the soil, however, or when a crust forms after rain, the entry and movement of air is interfered with and the plant suffers. This is one reason why the maintenauce of "tilth" and breaking of *karand* or *papri* which forms on the surface after rain or irrigation is important: this is realized in practice by most zemindars. The importance of *anhi godi* (blind hoeing) for sugarcane before the shoots are above ground is largely connected with this factor. The æration of the soil in case of young rapidly growing plants is very important. It may be noted that ripe seed respires, as the young embryo cannot otherwise live. The germination of old seed is probably defective, because part of the food store has been exhausted in this way.

Reproduction.

We have now described the ordinary life processes of the growing plant which consist in absorbing water and mineral matter from the soil, assimilation of carbon dioxide and formation of carbohydrates and proteins, and the burning up of a small part of the former in respiration. When the plant has made sufficient vegetative growth the process of reproduction starts, and continues along with the vegetative growth. In plants reproduction may be (*a*) vegetative or (*b*) sexual.

The process of vegetative reproduction may be illustrated in the case of potatoes, where under-ground tubers become enlarged and each eye-bud can give rise to a separate plant when replanted. Sweet potatoes are reproduced by planting the stems. Sugarcane, which seldom flowers in the Punjab, depends entirely on vegetative reproduction. Several grasses, *e.g.*, *dub*, *baru*, etc., also reproduce themselves mainly in this way. Similarly onions and turmeric form bulbs for reproductive purposes. Gardeners reproduce roses and many other garden plants in this way. In vegetative reproduction we are merely expanding or splitting up the parent plant into a number of exactly similar ones. *This is very different from the sexual reproduction of* animals and plants. In the latter one cell after fertilization by another cell, often derived from another individual, gives rise to a new animal or plant which may be distinctly different from one or both of its parents. If a flower be carefully examined, it will usually be found to contain inside the coloured petals a central female portion surrounded by many male portions. The female portion, "pistil", contains one or more egg-cells, which are formed in a similar way and serve a similar purpose to the egg-cells of a female animal. On the upper part of the pistil will be found a surface ("stigma") designed for the reception of the dust (or "pollen" grains) formed in the male organs (anthers). When one of these pollen grains from the male portion of a flower falls on to this stigma, a tube is formed which grows down into the pistil and fertilizes the ovule or "egg" in the female part of the flower. This tube can only be seen with a microscope. In some flowers the pollen always, or almost always, comes from the male part of the same flower, *e.g.*, wheat; in others, such as cotton and *taramira* (*Eruca sativa*), pollen grains in a considerable proportion at any rate, come from other flowers or plants. The flowers of many plants are so constructed as to ensure the certainty or probability of the pollen coming from another flower. In many cases such provision is made by the stigma and anthers on the same flower regularly ripening at slightly different times. In other plants, such as the date-palm, the flowers of any particular tree contain only the female or the male portion of the flower, as the case may be. When the pollen comes on the stigma from the same flower, it is called self-fertilization ; if from another flower, cross-fertilization. The transference of the pollen from one flower to another in cross-fertilization may be merely due to its falling or being blown by wind; but it is often carried by insects, and in many flowers honey is produced, which attracts insects.

The *ovule* or *egg-cell* in the female portion of the seed is contained in a skin which eventually becomes the seed-coat. After fertilization this seed-coat swells and the fertilized egg-cell develops into the very small young plant (embryo) which can be found in any seed. The last stage of the development of the seed consist in the storage in it of the food material for use in germination, and, lastly, the drying up with a diminution in thickness of the seed coat. This food material may be stored in the two first formed leaves (cotyledons,) which are then more or less thickened, as in the case of gram and turnip, etc.

These leaves may (as in gram) remain in the seed after germination, functioning merely as food stores, or they may be brought above the surface and function for a time like ordinary leaves (*e.g.*, turnip.)

The food in the seed, wherever it may be stored, consists of proteins, carbohydrates and fat. Protein is always present in considerable proportions, forming more than 10 per cent. of wheat and barley grains, and nearly 20 per cent. of gram and cotton seeds. The proportions of carbohydrates and oil, however, vary greatly in different seeds. Thus, in wheat or barley there is only 1 per cent. or 2 per cent. of oil and 66 per cent. of carbohydrates, whereas, cotton seed contains about 20 per cent. of oil and only some 15 per cent. of carbohydrates. A point of some importance to the farmer is the fact that a large amount of the nitrogen and phosphorus absorbed from the soil is eventually transferred to the seed, whereas much of the potash taken from the soil remains in the leaves and stem of the plant. Thus by the sale from the farm of the seeds of crops such as wheat and oil-seeds whilst retaining the remainder of the plant, we are parting with much of the phosphorus taken from the soil by the crop, but are not losing much of the potash. Conversely the manure from animals receiving large quantities of cotton seed and gram is much richer in nitrogen and phosphorus than that from animals not so well fed. This is another of the reasons why phosphatic manures are more likely to be needed than potash salts in the course of ordinary farming where the stems and leaves of the plants are not sold. For the same reason the ashes of wood, cotton sticks, etc., must be regarded mainly as potash manures.

It has been shown that the seed consists of the seed-coat, the young plant (embryo), and a food store. One or more of these seeds are enclosed in the female part of the flower, which, when ripe, is spoken of as the fruit of the plant. The boll of cotton plant, the pods of gram or *toria* are examples of fruits in which this structure can be plainly seen. When the fruit dries up, it either breaks open and liberates the seeds, or the whole fruit falls off the plant containing the seed within it. The cotton plant affords an example of the former method; the wheat grain which falls out off the straw of wheat is really a fruit enclosing one single seed; and oranges and melons are examples of fruits containing several seeds. The so-called "seed" of the beet-root is also really a fruit containing several seeds, as is easily seen if one is cut or broken up.

In nature these seeds or fruits are spread about more or less widely by various agencies, of which animals, birds, and the winds are the commonest. The seeds or furits of many plants are very obviously and specially adapted for being carried by wind, or becoming attached to passing animals, or to be attractive food to animals or birds. The seeds of *pohli* (*Carthamus oxycantha*), the seeds of the grass called *kutta ghas* (*Cenchrus echinatus*), and the edible grains and fruits respectively afford examples of these three different adaptations for dispersal.

With wild plants only so many of the seeds will germinate as happen to meet with the right conditions. But when a farmer is growing a crop he has to meet the expenses of rent and cultivation of the whole of his field. If his farming is to be profitable, he must sow his seed so that they will germinate in every part of his field. This means that he must sow the seeds everywhere under such conditions as are necessary for bringing them to active growth, or, in other words, for germination.

Change during germination.

The "embryo" in the seed after it is sown exists and develops for a time on the store of food material stored in the seed. The seed-coat has first to be moistened and softened. Some seed-coats are so hard that artificial methods have to be used to accelerate the process, *e.g.*, Java Indigo in Behar is treated with weak acid before sowing. After the seed-coat is moistened, the food material ferments and becomes soluble and available for the swelling embryo. All this requires moisture, and hence water is the first necessity for germination.

Necessity for moisture and right temperature.

There is a definite range of temperature for the germination of any particular seed. *Rabi* crops will generally not germinate in the hot season, whereas *kharif* crops will not germinate in the *rabi* season. This is a useful provision of nature, as it prevents waste through the seed germinating at the wrong time of the year, and the young plant subsequently dying owing to adverse weather conditions. Some seeds will not germinate after they are ripe until they have been exposed to certain changes by storing or in nature even though moistened and kept at a suitable temperature, *e.g.*, lucerne and clover.*

Importance of air.

Most seeds, however, will germinate as soon as moistened if kept at the right temperature and with fairly free access to air. Air or oxygen is the third essential condition for successful germination. Air is required for the respiration of the actively growing seed and also to facilitate the change of food material into a soluble condition. Small seeds are very sensitive in this respect and if planted too deep often fail to

* "Botany for Agricultural Students"—Martin, page 68.

start germinating. Once germination starts the young shoot can generally force its way through to the surface, so that failure to germinate is not due to mechanical causes so much as to insufficiency of air supply.

The essential conditions for germination can be demonstrated by simple experiments quoted in various text-books. Light is not necessary for germination. In practice the necessary conditions for germination are provided by sowing at the right season in moist fine earth which is sufficiently pressed down so that the seed is in close contact with it. The seed must not be sown too deep, and *the surface of the soil must not be allowed to get caked.*

In the germination of the seed the softening and swelling of the seed-coat is most prominent at the point where the root emerges (the micropyle). The root on emerging into moist soil soon develops root-hairs and small branches, and firmly anchors itself in the soil. Water is absorbed by the root-hairs to meet the need of the rapidly growing plant. By the *growing* and *lengthening* of the *young stem* the young plant (plumule) emerges, and on reaching the light develops green matter, and is adapted for manufacturing its own food, and is, therefore, established in life.

References

(1) Feeding of crops and stock by Hall.

(2) Agricultural Botany by Percival.

(3) Botany by Strasburger.

(4) Botany for Agricultural Students by Martin.

(5) Book of Rothamstead Experiments.

CHAPTER IV

CHEMISTRY OF SOIL

The soils of the Punjab plains are of alluvial origin, *i.e.*, deposited from water. They are coarse and fine according as the current from which they were deposited was flowing fast or slow. While the soils are generally speaking very uniform, considerable variation occurs even in different parts of the same field. The particles of which soil is composed vary in diameter from 2 millimeter in case of coarse sand to less than 0.002 millimeter in case of clay. Fine sand and silt occupy intermediate positions. The surface area of the particles in one cubic foot of ordinary light loam is about one acre, and even in coarse soils it amounts to ¼ acre. This large surface is being constantly exposed to the weathering influence of water and air as well as to that of chemical substances such as carbon dioxide and organic-acids produced by the activities of plant roots and micro-organic population. A cubic foot of dry soil weighs from 80 to 110 lbs. depending mainly on whether the soil is mostly clay or sand. An average soil may be taken to weigh 92 lbs. per cubic foot. The top nine inches of an average soil will, therefore, weigh about 3 million lbs. or 1300 tons per acre. A comparatively small proportion of this mass consists of plant food, as will be seen from a study of the soil analysis given below.

Analysis of hydrochloric acid extract of soil (square 27 Lyallpur Farm) percentage on air-dry soil.

	*Organic matter.	Nitrogen N_2	Total phosphorus P_2O_5	Potash K_2O	Lime CaO
Highest ..	0.82	0.052	0.21	1.30	3.22
Lowest ..	*0.14*	*0.026*	*0.14*	*0.76*	*0.82*
Average ..	0.48	0.041	0.16	1.06	1.67
Or in round figures ..	0.50	0.040	0.15	1.00	1.50
Per acre lbs. in top 9" ..	15,000	1,200	4,500	30,000	45,000
Per acre in tons ..	6.7	0.5	2.0	13	20

*The percentage of organic matter given in this table is 1/6th of that shown in a *similar table on page 23 of the 1st edition of the book*. This marked *difference* is due to change in the analytical method. The figures given in the first edition were determined by igniting the sample in the muffle furnace. This method is not considered accurate now-a-days, because most of the carbonates in the soil get broken up during ignition and are counted as organic matter. The modern method is to estimate the percentage of organic matter by oxidising the soil sample, thus avoiding the breaking up of carbonates.

Plant food in the soil.

As mentioned above soil consists of weathered rock particles of different sizes, containing a small proportion of organic matter in the form of humus. The plants derive their nutrients from the extensive surface of these particles by spreading their fine root-hairs in intimate contact with them. The bases such as calcium, potassium, magnesium, etc. are absorbed in their exchangeable form, while the nitrates and phosphates exist in solution. The fertility of soil depends upon its power to supply these nutrients in sufficient amounts. It does not matter how much total calcium, phosphorus or potassium a soil possesses, for, unless they are present either in an exchangeable or easily soluble form, they cannot support plant growth adequately. In view of these facts the usual total chemical analysis of soils finds little use. More useful purpose is served by analysing the soils for their exchangeable basis, available nutrients, the amount and kind of water soluble salts present and their reaction (pH values). Chemical analysis of some representative soils of the Punjab is given below.

Chemical Analysis of some typical Punjab soils.

Soil	Exchangeable bases (milli-equivalents).				Available nutrients.		Total N	*pH	Total salts.
	Sodium	Potassium	Calcium	Magnesium.	P_2O_5	K_2O			
Kangra	0.24	0.32	5.02	0.35	0.009	0.017	0.110	5.8	0.08
Lyallpur	0.62	0.64	4.52	0.86	0.063	0.041	0.050	8.0	0.15
***Bara* Soil**	5.10	0.10	0.65	Nil	0.098	0.061	0.030	10.0	0.65
Average for Punjab	..	..	..	..	0.042	0.022	0.041	..	..
Per acre—9" in lbs.	..	..	..	..	1,200	600	1,200	..	..

It will be seen that the usual amount of exchangeable bases present in Punjab soils is quite insignificant as com-

*pH value is a measure of active acidity and alkalinity. pH 7 is the point of neutral reaction. Values higher than this indicate alkalinity, and lower ones such as pH 6 or 5, indicate acidity.

pared with the total amount, yet they exercise important influence on the physical and chemical properties of soil. The average Punjab soil contains about 6-10 milli-equivalent of these bases per 100 gms. of soil (A milli-equivalent is equal to one thousandth part of a gramme equivalent of any chemical element or compound). In a good fertile soil 75-90 per cent. of these consist of Calcium and Magnesium. There are instances, however, where the major portion is formed by sodium *e.g.*, the well-known *bari* and *bara* soils. These soils are hard and highly impervious and in former days they were considered to be sterile. But a true understanding of their nature has led to the evolution of simple methods whereby they can be partly corrected and put under useful crops. In brief these consist in the substitution of exchangeable sodium by calcium either by addition of calcium salts like gypsum or indirectly by growing of rice and *berseem*. As regards the available nutrients it will be seen that the soils of the plains are low in total nitrogen but are well supplied with available phosphorus. Hill soils, like Kangra, on the other hand are low in phosphorus but are well supplied with total nitrogen.

The second chemical factor controlling the fertility of Punjab soils is the presence of alkali salts. In the hot and dry climate prevailing in the central and western part of the Province, there takes place an accumulation of alkali salts (sodium carbonate, chloride and sulphate), and in cases of excessive concentrations (usually 0.2 to 0.4 per cent.), they reduce the productivity of soils and even render them totally infertile. Such soils are generally improved by drainage and by growing salt-resistant crops.

In the canal colonies, particularly Jhang, it is a common practice to grow salt-bush (*Atriplex confortifolia*) commonly known as *lani, khar budi* or *sajji* plant, on alkali soils. These plants remove a fair amount of sodium salts and are, thus, considered useful for reclaiming soil. After harvest the plants are burnt in a pit and resultant ashes are used for washing clothes.

Physical analysis.

Besides chemical analysis, the chemist generally examines the soils physically by dividing it into several classes according to the size of particles. This is generally done by first reducing the crumb structure of a weighed quantity of soil by treatment with an acid which breaks up the cementing agents like calcium carbonate, preparing a soil suspension from it, and then pippetting out measured amount of samples after intervals of time based on the rates of settling of particles of different sizes due to gravitation. In this way the proportion of sand, fine sand, silt and clay in any particular soil is determined. Such examination of the surface soil only is not sufficient. It is a recognised fact that plants send their roots to the deeper layers also, and, therefore, it is essential to have a correct idea of the nature of soil below the cultivated horizon. This is called "profile examination." It must be admitted, however, that even with a detailed examination of this kind, not much can be definitely said about the fertility or otherwise of a soil. Of course, harmful substances, such as an excess of salts can be thus detected. If the person analysing the soil has experience of agricultural properties of land in the neighbourhood, he can form a much better judgment of the fertility than if he relied on analysis alone. This is the reason why "soil surveys" are so important and now form an essential preliminary feature of all new canal projects, where the canal has to irrigate hitherto unbroken land. The Sutlej Valley canals and Lower Bari Doab canal provide a good instance where a preliminary soil survey could have avoided expensive mistakes. Soils having more than 50 per cent clay are considered to be of limited use and are generally put under rice. Similarly soils with less than 20 per cent. silt and clay are considered to be too poor, both as regards their fertility and water-holding capacity. Both these extreme types of soils are, however, uneconomic under average conditions. Similarly soils where the sand layer appears at a short distance from the surface are considered to be unsuitable for growing deep rooted crops like cotton, and for fruit trees generally.

Plant food removed by crops.

As pointed out in a previous chapter the food constituents which are generally deficient for the needs of the plants are nitrogen, phosphorus and potash. The amounts of these removed by some of the important crops are given below:—

NUTRIENTS REMOVED PER ACRE.

Particulars.			Nitrogen	Phosphoric acid	Potash
			lbs.	lbs.	lbs.
Wheat 15 *maunds* grain	..	..	19.68	11.52	4.24
30 *maunds bhusa*	..	..	14.76	3.16	17.76
	Total	..	34.44	14.68	22.00
Maize 20 *maunds* grain	..	..	25.92	11.13	8.96
25 *maunds* fodder	..	..	12.81	7.98	22.89
	Total	..	38.73	19.11	31.85
Sugarcane 10 tons stripped cane	..	..	10.80	10.40	12.20
6 tons tops	..	..	17.3	4.90	12.10
	Total	..	28.1	15.3	24.30
Cotton 150 lbs. lint	..	..	0.32	0.12	1.00
290 lbs seed	..	..	9.50	3.44	3.34
5000 lbs. sticks	..	..	30.00	8.50	90.50
	Total	..	39.82	12.06	94.84

In the case of wheat and maize it may be noted that most of the potash is taken in the straw, whereas nitrogen and phosphoric acid are mainly in the grain. In case of cotton all the nutrients—N, P, & K are mostly present in the sticks. Their return to the soil would, therefore, appear very essential. From the amount of available nutrients given in the table (page 42) it can be readily seen that even the top 9" layer of soil which weighs about 3 million lbs. per acre contains enough nitrogen for about 40 crops of wheat. Similarly, of available phosphoric acid there is enough for 80 crops of wheat, but plants send their roots several feet down and draw food from lower layers. This being the case, the question occurs, why is it that soils respond so well to manuring and why do such small dressings of manure, which often only increase the nitrogen of the soil by one to three per cent result in such increase of yield. The answer is apparently that the plant food in manures is very easily available and the quantity given, though only a small proportion of the total present in the soil, is generally more than what one crop takes.

Nitrogen fixation.

The soil gets some nitrogen from the air in the form of nitric oxides after electrical storms through the subsequent rains or dew. The amount of nitrogen the soil gains in this way naturally depends upon rainfall and prevalence of electrical storms and is generally not more than 6 lbs. per acre, or $^1/_5$th of what a wheat crop requires.

There are two other natural sources, both dependent upon bacteria, for the replenishment of nitrogen supply in the soil. It has been known for almost a century that plants of the 'leguminosae' order ordinarily have colonies of bacteria living on their roots, which fix nitrogen from the air and thus render it ultimately available to the crops. The roots of the crops like gram, peas, *guara*, etc., if examined during growth will be found to have excrescenses, warts, or nodules sometimes as large as an eight-anna piece. These nodules are made by bacteria and their presence is very beneficial both to the parent leguminous plants and to the subsequent crops, which benefit from the nitrogen fixed during the life of the leguminous crop. Farmers have a practice of sowing legume-cereal mixtures in very light soils, which lack nitrogen. This has been found to have a scientific basis, because the leguminous plants obtain their nitrogen supply with the help of the nodules in bacteria and are able to transfer a portion of it to the cereal plants growing in association.

The second source of gain of nitrogen is from the action of bacteria living in the soil independent of crops. All healthy fertile soils have a large number of different kinds of bacteria living on the organic matter in the soil. Some of these add a considerable quantity of nitrogen to the soil by fixing it from the air and forming compounds, which ultimately are transformed into nitrates for the use of plants. The factors controlling this fixation are not well understood but it would appear that the process is very active in the summer and more so in dry years than in wet years. This point requires further investigation. It is known that in wet or water logged soils the opposite process, *viz.*, denitrification, is active. The figures given below show results of two cases studied by Mr. Wilsdon.

Particulars.	Fallow		Green Manure Experiment.	
	May	October	May	October
Nitrogen.				
I. (a) Percentage	.0362	.0375	.0314	.0331
(b) lbs. per acre	1086	1125	942	993
(c) Addition	..	39	..	51
II. (a) Percentage	.0251	.0282	.0226	.0262
(b) lbs. per acre	753	846	678	786
(c) Addition	..	93	..	108

It will be seen that in No. II the addition is more than twice that in No. I. Even the lowest figure of 39 lbs. is equivalent to the total nitrogen content of a crop of *guara* weighing 240 *maunds* per acre when cut. If this crop were ploughed into the soil instead of being cut and used elsewhere the addition to the soil nitrogen is about 40 lbs. per acre only. Nitrogen fixation appears to be much more active in the Punjab than in Britain. This probably accounts for the remarkable fertility of some of the soils of the Punjab though receiving no manure. The treatment of the soil during fallow must have a very marked effect on the fixation process, but as so little is known of the controlling factors very little can be said at present.

Work done on rice by Harrison showed that crops gain appreciable quantities of nitrogen, either in the way described above, or by association with algae growing in the water round the plants.

This matter has been briefly dealt with in chapter III.

Form in which plant food is available.

It is necessary to emphasise in the case of nitrogen that plants are almost invariably able to take this element in the form of nitrates only. The change from complicated organic compounds into nitrates is mainly carried out by bacteria. These are quite distinct from the bacteria referred to above as effecting fixation of nitrogen in the soil. Good cultivation facilitates the process of ı trifying whereas under unfavourable conditions, such as with water-logging or poor cultivation, the process is hindred, or in some cases the reverse, *viz.*, denitrification takes place.

References

1. Book of Rothamstead Experiments.
2. Wheat analysis by Leather, Agricultural Ledger Vol. X.
3. Southern field crops.
4. Field crops for the cotton belt.
5. Chemical analysis of the Punjab Soils (figures supplied by the Chemical Section, Punjab, Agricultural College, Lyallpur).

CHAPTER V

PHYSICAL NATURE OF THE THE SOIL AND CULTIVATION.

Importance of tilth.

The ability of a soil to yield good crops depends very largely on its physical condition or "tilth". This must be distinguished from the "physical nature" of the soil which generally depends on the proportion of sand and clay in it. Other factors controlling the yield, such as "plant food" and water, are affected by the tilth, and hence this matter is of great importance. It cannot be said that we know definitely what constitutes good tilth, nor have we any means of measuring this property exactly. We do know, however, what influences the physical condition beneficially or deleteriously.

Definition.

It is probable that an essential feature of a soil in good physical condition is what is termed a "crumb" condition.* This means that the individual particles of which it is composed are largely aggregated together. This aggregation enables the soil to hold more water and leaves more surface for the root hairs of the plants to spread over, as well as allowing bigger spaces for storage and movement of air in the soil. The latter is now regarded as an essential condition of fertility.†

Whatever constitutes good tilth, there is no doubt about its immense importance, and good crops of high quality cannot be obtained in a soil in poor tilth even if large quantities of plant food are added in the form of manures and the water supply is abundant. On the other hand, a good crop can be obtained from a soil in good tilth without any manuring and with a minimum amount of water.

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*King's "Physics of Agriculture," page 108.

† Howard, Pusa Bulletins No. 61. of 1916.

Distinction between texture and tilth.

The physical nature of the soil or its "texture" depending, as it does, on the proportion of stones, gravel, sand, silt and clay in it, is permanent, and cannot be varied appreciably by ordinary farming practices. These physical constituents can be separated in the laboratory, and will be found to be constant for any particular soil whatever processes of cultivation are employed. The physical condition of the soil or its "tilth" depends, however, on the way in which these particles are arranged. Tilth is, thus, a temporary condition and is liable to be affected by every influence acting on the soil, as, for instance, cultivation, watering or drying. It is, therefore, at present impossible to measure or even define exactly what "tilth" means.

Condition of sub-soil.

Again the roots of plants penetrate down into the soil to a depth of several feet; in the case of cotton the roots have been traced at Lyallpur to 15 feet depth. It is evident, therefore, that the physical condition of the soil below the top 6 or 9 inches, which is cultivated, affects the crop. The main agent in loosening the soil below the first 6 or 8 inches is the roots, themselves. The roots force their way in all directions and when they decay they leave open spaces for air and water, and the organic matter left serves to manure the sub-soil in the same way as dung or leaves do the surface soil.

Case of new soils.

It is probably due to the fact that the lower soil has not been properly opened up that the first crop or two on new land is inferior and apt to disappoint the inexperienced. The same soils after a couple of crops yield very heavily as a rule.

Rotation.

One of the advantages of rotation of crops also lies in the fact that deep rooting crops such as cotton, gram, etc., open out the soil excellently for the succeeding wheat crop. At Lyallpur wheat following cotton has given 10 per cent. higher yield over a number of years than wheat following wheat.

The drying of the soil, which occurs to a depth of 2 or 3 feet after prolonged drought, must exert an influence on the sub-soil also. We know soils expand when wet and contract and crack on drying. Ordinarily every soil is moist below the top few inches, but after a prolonged drought the soil seems to get dry to a greater depth. It has been found at Lyallpur that summer fallow cultivation with a minimum of rain or watering has a better effect on the succeeding wheat crop than when water is applied or a wet year ensues. This loosening of the sub-soil by means of deep-rooted crops or by drying seems to suit crops like wheat and barley especially. The roots of these crops spread freely to a depth of 5 or 6 feet at least in such a soil, whereas they are unable to do so in hard sub-soil. Cotton is better able to force its way down into hard soil, and the condition of the sub-soil in its case would not appear to be so important. Maize and sugarcane, which are shallow-rooted, do not seem to be affected by the condition of the soil below top 2 feet or so.

Other agencies affecting lower layers of soil.

The relative importance for various crops of loosening the sub-soil has been discussed above, but the condition of the surface 6 or 9 inches is of vital importance to all crops. All crops are sown in this surface layer and draw their entire mineral nourishment from this source during the first few weeks of their existence. Pests, unfavourable weather and other adverse factors are most potent at this stage in the life of the crop, so that its future is very largely dependent on its condition in the early stages of its growth. Again, most crops have 80 per cent. of their roots in the first 12 inches of soil. The tilth of the surface soil is very largely in the power of the farmer. It is the difference in the physical condition of this surface layer which is responsible for the good yields on well-farmed soil as compared to similar land indifferently cultivated. This is especially true for the Punjab, where manuring is comparatively rare except for certain crops. This emphasises the importance of cultivation as the only practical means of improving tilth that is within the reach of the farmer here. First class crops can be obtained on

Importance of top layer

the alluvial soil of the Punjab with good cultivation and sufficient water without any manuring.

Tillage operations.

Tillage operations may be divided into three classes—the fallow or preliminary cultivation, the operations connected with the sowing of the crop, and the after cultivation or intertillage of the growing crop.

Fallow cultivation means the cultivation of land when it is resting. It should usually begin as soon as possible after the harvesting of the previous crop, and may be considered as ending when we start to prepare the seed bed. On irrigated land the beginning and ending of this period are generally sharply defined by two waterings. After the removal of the previous crop a watering called *wahn* is commonly applied in order to make it possible to plough it, and thus start the fallow cultivation; shortly before sowing another watering is applied called *rauni* and after this the soil is prepared for sowing without any further watering. If timely rain falls, the *wahn* irrigation is unnecessary.

The second class includes the preparation of the soil for sowing, and the sowing and covering of the seed. This operation may be regarded as ending when the young crop emerges from the soil.

Intertillage means the cultivation given to the crop after germination and during the growth of the crop. This is facilitated if crops are sown in lines some distance apart.

The cultivation of the soil in which the crop is growing is usually possible with suitable implements, and is very profitable provided that too much of it does not have to be done by hand labour.

For all these various operations the Punjab farmer uses, ordinarily, only implements drawn by a pair of bullocks, the country plough and *sohaga* supplemented by several hand tools. For fulfilling a large variety of functions these implements are unquestionably very efficient, especially when their small cost (a few rupees each) is considered, as well as the fact that very little iron is used in their construction; for until recent years iron was too dear in India to be used profitably in such things as agricultural implements. But naturally an implement, which is used for a variety of purposes, cannot perform each of them so efficiently as an implement designed for that special purpose. Hence, so long as the limit at which the interest on capital expended becomes too great is not reached. it is profitable to employ a number of different cultivating implements, such as ploughs, harrows, and hoes. Each of these implements is designed for only a very limited function, but will perform that function very efficiently and cheaply.

As has already been explained, land from which one crop has been harvested, and which is resting until the sowing of the next crop, is called fallow land. The changes in the store of plant food in the soil which take place during such a fallow are discussed elsewhere. The objects of cultivating the soil during such a period are to facilitate these chemical changes, to improve the physical condition of the soil, and to free it from weeds. In English agriculture the cleaning of the soil from weeds is the most important reason for fallowing. But in the Punjab, where weeds only grow freely when the soil is watered, or during the short rainy season, the fallow, though still important as an opportunity for cleaning the land, is more a means of storing up fertility rather than a necessity for the control of weeds. The fallow period may be extended for a whole year, as is the case in many districts on *barani* lands, where wheat is followed by a summer *kharif* crop such as *mash, mung* or *moth*. The land in this case is fallow for over a year until the next wheat crop is sown. In irrigated land the fallow is generally short, *e.g.*, only a few weeks in case of cotton following *toria*, gram or sugarcane. Even in irrigated land wheat follows a fallow of some months, and is very rarely sown after a *kharif* crop. Gram, on the other hand, often follows summer fodder crops such as *chari* or *guara*.

Fallow cultivation is generally done in the summer either after rain or with irrigation. Very little land as a rule is vacant during the winter, especially in irrigated areas. In *barani* areas some winter fallow cultivation may be done if rains are good.

What fallow cultivation consists of.

Fallow cultivation consists generally in ploughing the surface soil so as to expose as much as possible of it to the weathering influence of sun, air and wind. If the *desi* plough is used, this means two or three ploughings, one of which will be crosswise. With the iron plough one ploughing is sufficient as a preliminary measure. The land is often left in fairly rough condition, but it should not be in big lumps or clods if this can be avoided. After the preliminary ploughings the land is stirred periodically either by a native plough, or by a harrow if it is available. The latter is preferable. The object is to bring the soil into a fairly level and fine condition before final preparation for sowing takes place. Fallow land should always be stirred after rain, as otherwise the surface hardens and big clods may be formed. Owing to its slowness the plough is obviously not the best implement for this work, for a harrow doing 3 or 4 acres a day can easily cover the ground before the surface soil gets too hard.

Advantages of the iron plough for fallow cultivation

By using the iron plough in the first breaking up of fallow land the soil is turned over and stubbles as well as weeds buried, thus enriching the soil. The *munah* tends to collect stubbles on the surface, and thus depletes the soil of fertilizing matter. Again the *munah* owing to its shape cuts a V-shaped furrow and leaves a considerable amount of soil untouched. This is why several ploughings with the *munah* are necessary where one with the iron plough suffices at this period. Again, apart from its inefficiency in burying organic matter the *munah* penetrates hard soil with difficulty, and when strong weeds are encountered, the draft is excessive.

Weeds such as *kahi*, *baru*, *motha*, and even *dub*,* tend to spread if only the *desi* plough is used. The exposure resulting from inversion by the iron plough causes the roots to dry and tends to clear the land of weeds

*For botanical names see chapter on weeds.

This aspect was very clearly noticeable when comparing two series of plots at Gurdaspur Government Farm. The only difference in the treatment of these plots was that in one the iron plough was used for the beginning of the fallow cultivation and the *munah* in the other. The latter plots were often full with *baru* and *dub* grasses, whereas the former were quite clean and free from weeds.

Again, owing to the iron plough cutting through the soil instead of tearing through it, it is possible to plough to the proper depth from the first, whereas with the *munah* the required depth of 5½ inches or so is often properly attained only by the third ploughing.

As pointed out above, it is not necessary for the soil to be in a fine state at the beginning of a fallow. Clods upto 3 or 4 inches across may be safely left, for they will mostly break down in the subsequent cultivation and by weathering. If too big, however, they harden and are very difficult to break up again if this is not done at once by means of the *sohaga*. If the *sohaga* is used it is necessary to plough again at once in order to open the soil. It is very common in the canal colonies to see fallow fields with big clods of this kind, as the farmer has neglected for some reason to *sohaga* and plough again at the proper time. Such land requires very heavy *rauni* waterings, and its tilth is never ideal at seed-time. The mould-board of the iron plough has a pulverising action, and large clods are rarely left after its use if the land was anywhere near the right condition (*vatar**) at ploughing time. Subsequent to ploughing either with a *munah* or iron plough, if an implement like the spring-tined-harrow or the horse-hoe is used, the clods can be easily broken at very little cost as compared to frequent ploughings.

The subsequent tillage of fallow land depends largely on rain. It should be, as pointed out above, broken up always after rain and before the surface hardens. This is easiest done with a harrow which can do 3 or 4 acres a day.

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*Land is said to be in "*vatar*" when it is in a fit condition for ploughing after irrigation, and will break up easily when implements are used over it. Cultivation at this time saves labour and trouble afterwards.

If no rain falls, harrowing once every three weeks or a month is sufficient cultivation, and this tends to help the weathering and levels the soil prior to *rauni*. Before applying *rauni* it is advisable to use the *sohaga* to level the soil and assist the flow of water, thus, getting a more even distribution and economising water.

The above description applies in the main to irrigated and *barani* fallow cultivation. In the latter, however, the preservation of moisture is of primary importance. Hence, cultivation after rain to preserve moisture is most essential. The ideal thing in *barani* land would be to break the soil before rain, but this can, generally, only be done by a disc plough or disc harrow, and the cost of these is prohibitive for general use.

If only indigenous implements are used, every rain must be taken full advantage of and the land ploughed as deep as possible. As a rule, subsequent rains enable the proper depth to be reached by the second or third ploughing. The clods should be broken up by *sohaga* towards the end of the period, but it is inadvisable to have the surface fine and smooth, as in that condition rain destroys tilth easily. Attention to summer fallow cultivation at the Gurdaspur Government Farm accounts for the generally much better yields obtained there as compared to surrounding *barani* fields of similar quality. Recently, very comprehensive research into the methods of Dry Farming has been conducted at the Rohtak Agricultural Farm, and very valuable results have been achieved. The results are briefly given below*.

(1) *Contour levelling.*—The land should be levelled as much as possible.

(2) *The kiara system.*—It should be adopted because in practice it has been found that *bunds* (9 to 12 inches high) both at the boundaries and across fields under *barani* cultivation are as important as they are in irrigated fields. Temporary *bunds* can be made easily with a Hindustan plough.

*Departmental Leaflet No. 160.

(3) *Weeding and interculture.*—No weeds should be allowed to grow in fields lying fallow or in standing crops because weeds remove water from the soil. Occasional harrowing with a blade harrow or Lyallpur hoe will suffice for the purpose. A blade harrow costs Rs. 5 only and can be prepared by a village carpenter.

(4) *Area equally divided between kharif and rabi, crops.*—The land should be divided into two parts, in one only *kharif* crops should be grown while the second portion should be kept for *rabi* crops. In this way if the crop fails in one season a return may be obtained in the other.

(5) *Fallowing.*—In certain years it so happens that the annual rainfall of a locality is so low that it is not possible to raise a crop every successive year, due to lack of adequate moisture. By keeping the land fallow it is possible to carry over the moisture from one year to another and raise a successful crop of *bajra* and *guara* on the combined rainfall of two years, if it is conserved carefully by keeping the land free from weeds during the "fallow" year.

As the rainfall in *barani* areas is very uncertain, and insurance against entire famine will be provided if each year a small portion of a holding, say, one or two acres is kept altogether uncropped but continually stirred and cultivated. This small area will produce a successful crop of *bajra* and *guara* during *kharif* of the next year, even though the summer rainfall may be very light.

(6) *Rotation of crops.*—There should be a definite rotation of crops; cereals and millets may follow leguminous crops and *vice versa*. For instance, *juar* and *bajra* may be rotated with gram, while wheat and barley in the *rabi* may be followed by *guara* and *moth* in *kharif*.

(7) *Timely seed-bed preparation.*—In September, deep and fine seed beds should be prepared for the

rabi crops. For this purpose the *desi* plough is quite efficient. If its use can be combined with an harrow there is nothing better.

(8) *Conservation of farm yard manure.*—Poor soils which ordinarily cannot produce a normal crop under favourable soil moisture conditions should be manured with farm yard manure at 5 tons per acre or at the rate of two carts per *bigha.*

There is undoubtedly a large scope for the introduction of more suitable implements on *barani* tracts so as to make full use of the draft power available.

Implements suitable for fallow cultivation.

The implements which would appear to be most useful for *barani* tracts are horse-hoe and spring-tined harrow. They are rather expensive. Disc-harrows, though still more suitable, especially for heavy land, are too expensive to recommend. The two implements will cover from 3 to 5 acres a day, and their work resembles that of the *munah* in that they stir the soil without inverting it. They enable the cultivator to cover his whole fallow area quickly, and thus, in case of only light preliminary rains, the subsequent ploughing is easier. If early rains are sufficient, they enable the soil to be put in a condition which conserves the moisture through the surface mulch. The land can be then ploughed at leisure. It will be seen that harrowing in *barani* land is of great importance, but ploughing should also be done as early as possible in the following season, and for this the furrow-turning iron plough is recommended.

The practice in irrigated land of giving a *rauni* watering, even if the rains have been fairly good and the soil contains fair moisture, is general. One of the reasons for this is that *rauni* does not destroy tilth as the soil is cultivated afterwards when in *vatar*. The giving of a watering may help to delay the date of *kor* or first watering after sowing, and this is everywhere regarded as being good practice. There is no doubt that once *kor* watering is given the presence of the growing wheat crop prevents much being done by tillage to keep the land in tilth. Harrowing by means of the bar-harrow does some good, but to be really deep enough to get perfect tilth would cause injury to the young roots of the crop. Thus, once a thickly growing crop like wheat is sown, very little can be done by way of effective after-cultivation.

Period between *rauni* and sowing.

After *rauni* irrigation the land is in *vatar* and ready for sowing in the hot season after 2 or 3 days in the case of light land, and 3 or 4 in case of heavy land. In October, or at the beginning of the *rabi* sowing season, the period is about 5 or 6 days, and later 10 to 12 days. As a rule, sowing should be done as soon as land is in *vatar*, and this is especially so in case of shallow sown crops like *toria* and cotton. While at the beginning of the wheat sowing season it is advisable to sow as soon as the plough can be used on the land, *i.e.*, in 5 or 6 days after *rauni*, later on in November, when the land may take 8 to 10 days to come to *vatar*, it is a common practice to do *dab*. This consists in giving the land two or three ploughings at intervals of 4 or 5 days between time of *vatar* and sowing. This undoubtedly causes some loss of moisture, but is very useful in cleaning land, as weeds, such as *piazi*, which germinate at this period, are effectively destroyed by the cultivation given. *Pohli*, which germinates later, is not affected. This process is only advised in case of weedy soils and where western implements are not available.

Condition of seed-bed for various crops.

In irrigated land the surface should be as level as possible to facilitate even distribution of water during irrigation. Generally the soil should be uniformly fine and soft for the reception of the seed. It is not advisable to have too great a depth of loose soil, as otherwise the passage of moisture upwards is retarded. To compact the seed bed somewhat, the *sohaga* is used in ordinary practice. If necessary it is weighted by two men standing on it. After this compaction the actual surface may be harrowed to a suitable depth, thus forming a mulch for preservation of moisture. Even in case of *toria* a shallow mulch of 1 inch depth appears advisable. Cotton can do with 2 inches and wheat with even 3 inches. The mulch must not be deeper than the depth at which the seed is sown.

In the case of some crops, *e.g.*, gram the surface is often left irregular with even small lumps or clods of earth. This crop is generally sown deep in light soil, and if thus sown after the plough, it is generally not subjected to *sohaga*, as that might obstruct the passage of the young shoots above ground, and also mainly as it would make the soil less open for air. Throughout the treatment of the seed-bed it is necessary to keep the moisture fairly near the surface, as once it dries by being left long in a loose condition, it is difficult to get the moisture up again. This point is of great importance with summer crops when land dries very quickly, and where in consequence the right condition for sowing is more difficult to attain and keep up. The seed itself must be deposited in moist, fairly compact soil in all cases. The bar-harrow is extremely useful in connection with the formation of a surface mulch after sowing.

Advantages of country plough.

In the work of preparing the seed bed the country plough has an advantage over the iron plough in that it does not spoil the level of the field. And as the soil at this stage is usually already soft and loose, the country plough and *sohaga* will do quite good work. The *sohaga* is used after each ploughing to break the soft clods thrown up by the plough, and will give a finishing touch to the levelling if this is needed. In parts of the districts of Multan, Muzaffargarh and Jhang, and also in Rohtak and Karnal, a wooden roller is used instead of the *sohaga*. As explained elsewhere (Chapter VI), the roller is more efficient in the breaking of clods; and the compressing effect of the roller goes deeper and compacts the soil into the sub-soil. It is, thus, more effective in bringing the moisture to the surface than is the *sohaga*, the effect of which is more superficial. The roller may be necessary *in those parts where the soil is heavy and the inundation* canals close early. It would, sometimes, be useful in other parts also. But it is believed that it would not be advantageous generally to replace the *sohaga* by the roller on irrigated land, as the levelling effect of the former is so important. A roller should only exceptionally be needed for clod crushing on irrigated land under good management, and with perennial irrigation a perfectly moist seed-bed can be ensured with little difficulty.

Case where iron plough is used.

Generally the country plough is advised for operations just before sowing in preference to the iron plough except when no fallow period is available. Thus, when sowing cotton after wheat or gram, it is best to use the iron plough to bury the stubble. It must, however, be followed by the *sohaga* and harrowing in order to ensure the land being level before sowing.

Seed-bed in *barani* land

The process is similar to that on irrigated land except that the preservation of moisture and of a moist seed-bed is more vital. The former is attained by repeatedly working the *sohaga*. It has been suggested that the roller might be used with advantage. The matter is one worthy of careful study. The main difficulty is an economic one, and it might be difficult to recommend an implement which in some years of good rainfall may not be required. There are, however, probably several tracts where the use of the roller could be extended with profit.

Sowing.

In sowing we have to ensure not only plentiful and regular germination, but the thriving of the young plant during the first few weeks of its growth. The conditions necessary for germination are given in Chapter III. The three essentials are air, moisture and the right temperature. To ensure air the seed would be best deposited in loose soil near the surface. In this case, however, with the dry climate of the Punjab, the moisture supply would be inadequate and the seed, even if it germinated, might wither up. To ensure moisture, therefore, the seed must be in compact soil in touch with the reserves of water below. If planted too deep, the air supply may be deficient and the young plant may find it physically impossible to force its way through. This, probably, accounts for the practice referred to above as common in *barani* land to sow wheat and gram by *pora*, and leaving the field open without using a *sohaga*. The seed is thus left in touch with moist firm soil with quite loose soil above, and can thus on germination force its leaves above surface easily. In irrigated land, where optimum conditions of moisture are more easily attained, seed is sown usually much shallower than under *barani* conditions. Irregular germination of seed means a loss of yield even if actually a sufficient number of plants eventually germinate. The late plants never thrive as well as others, and thus start with a handicap. When the germination is so faulty as to leave blanks or patches of soil without plants, the loss in yield is considerable. It is estimated that from this cause alone cotton and *toria* in the colonies suffer to the extent of at least 10 per cent.

Temperature.

As regards temperature, the question mainly affects *rabi* crops. Early sown wheat, if the soil is not cool, is often lacking in vigour and very liable to attack by white-ants, or to suffer from early frosts. Again very late sown wheats are so backward that the yield is depressed often 30 per cent. or more. In irrigated land the sowing is determined by the supply of water, and necessarily extends over 6 weeks or 2 months. In this respect *barani* land has an advantage as date of sowing there is governed mostly by labour available. In irrigated land, sometimes, in order to avoid waiting for the land to dry sufficiently for sowing after *rauni* the seed of late sown wheat is put in before *rauni* in dry soil. In such cases it is very advisable to harrow when the land is in *vatar* or when the young crop is a couple of inches above ground.

Methods of sowing.

In the Punjab there are three methods of sowing commonly used for field crops—*chhatta* or broad cast sowing, *kera* or dropping seed in the furrow behind the plough, and *pora*. In the last method the plough is used as a one-row drill by tying a tube behind it.

The well-known proverb *pora badshah, kera wazir te chhatta fakir*—would suggest that *pora* was invariably the best under all circumstances. As applied to a crop like wheat and gram, it is probably in the main true, particularly, under *barani* conditions. For small seeded crops, however, broadcast sowing is essential. The machines used in the West for such seeds are essentially mechanical broadcast distributors. Even in the best farming districts in Great Britain, broadcast sowing by hand is still common. The two main defects of broadcast sowing are (1) uneven distribution and (2) irregular depth of burying the seed. The latter is a question of good management and cultivation, and is not generally serious. The former, however, is important. A great deal depends on the skill and patience of the sower. A good practice is to go over the land two or three times, *i.e.*, dividing the seed into two or three lots and sowing two or three times, as the case may be. Also if the seed rate is small and the seed of small size, it is advisable to mix it with dry earth, and thus, get a bulk more easy to distribute evenly. Broadcast sowing is eminently adapted for such crops as *toria*, *sarson*, *senji*, *shaftal*, etc.

In the simplest form of broadcast sowing, the land is watered (*rauni*), the seed is scattered on the level ground as soon as it is dry enough. The seed is then covered by giving one ploughing, followed or not according to circumstances by the *sohaga*. In fact, in the case of *senji*, when sown, as it usually is between the plants of ripenings crops of cotton or maize, the seed is simply scattered on the soil whilst it is still very wet, and buried by making the water muddy with the bare feet.

Ordinarily, however, the soil is allowed to come into a suitable condition for ploughing before the seed is scattered, and the land is ploughed directly after the sowing. It will be observed that in these cases the seed-bed is not prepared at all, and the only cultivation the soil receives is this one ploughing. This is the roughest, cheapest and quickest method of sowing possible. It is useful in the case of crops which are able to establish themselves in a rough seed-bed, and which are so uncertain, or give such a comparatively small return that the farmer's profit is likely to depend more on the reduction of the cost of cultivation than on ensuring a maximum return. It is such reasons that justify this method for sowing gram, especially in the *wadh* of another crop such as *chari* or for sowing *kharif* crops on *barani* land. The promptness with which considerable areas can be sown as soon as the soil is cleared of another crop, or as soon as it is dry enough after rain or watering, is another advantage of this method, and sometimes a matter of considerable importance. This also helps to justify the use of this rough and ready method in the two cases already instanced and also in the sowing of cotton on wheat stubbles. At the best, however, this is a very crude way of doing broadcast sowing, for the soil is left very rough, the seed is very irregularly covered, and much of it cannot be properly brought into contact with fine earth. It is a rough method, which is never really good, and would be fatal with crops that were not very hardy. *Chhatta* system is more common in Sialkot and Gujranwala districts even with wheat.

Ordinarily the seed bed is more thoroughly prepared by some degree of cultivation, and using the *sohaga* to get the soil level and compact. The depth of sowing is regulated by the kind of surface on which the seed is sown and by the method of covering. For very shallow sowing, the seed, when sown on land after the *sohaga* has levelled it, is covered by dragging a bushy branch of the *kikar* tree over the land. *Toria* and *sarson* are often sown on land left rough after the native plough and the seed is covered by levelling with the *sohaga*. Again the soil may be levelled with the *sohaga*, seed sown, land ploughed and gone over with *sohaga*, afterwards. This tends to get the seed deeper than is suitable for *toria*. The deepest sowing is done by sowing on a rough surface after ploughing, ploughing again, and using the *sohaga*.

There is little doubt that if harrows come into general use, a great improvement can be made in this method of sowing, for with harrows it is possible to control more accurately the depth at which the seed is covered, and, besides, they cover three or four times the ground done by the *munah*. The *sohaga* or some similar implement will, however, need to be used even with harrows so as to leave the soil fairly compact.

Kera is used generally on irrigated land, where the seed-bed has been brought to some degree of fineness. It consists in a boy or woman following the plough and dropping the seed in the furrow a few yards behind the ploughman. The next furrow throws an inch or two of soil over this, and by the subsequent use of the *sohaga* the seed is covered 3½ inches or so deep. This method is much in vogue in the canal colonies for wheat, and to some extent for cotton. The depth of sowing by this method is not very flexible, and it is unsuitable for that reason for use with small seeds. Much skill is not required, as in the case of *pora*, and the method is therefore very common in irrigated and to a less extent in *barani* land. The land in irrigated tracts has to be levelled with the *sohaga* to facilitate subsequent watering.

Kera sowing.

In sowing with the *por* a seed tube (*por* or *nali*) is attached to the plough in such a way that the seed drops just behind the *chow* in the *munah*, and under it in the case of the *hal* as in the latter it passes through a hole in the *kur*. The seed is thus deposited right on solid earth at the botttom of the V-shaped furrow, and is partly covered by soil falling back behind the plough. The next furrow adds still more soil. Usually the *sohaga* is not used after *por* sowing, as the seed would thus be too deeply covered. In this method the ploughman drops the seed into the funnel-shaped mouth of the tube. As some blanks are apt to occur in turnings, it is a common practice to sow a few rows diagonally across the fields after finishing in the ordinary way. Shallower sowing can be done, if necessary, by taking the *por* higher and further from the *chow* so as to imitate *kera*. This is not common, but is sometimes done on well-irrigated land. The *pora* system is generally used on *barani* lands.

Pora.

By sowing with *drills* (see Chapter VI) the seed is dropped in much the same way as by *por*, except that the quantity is regulated by a number of tubes. There are two tubes in the case of *kharif* drills and three in *rabi* drills. The most important advantage of using drills is that it facilitates after-cultivation in case of *kharif* crops. In the case of *rabi* crops, time is saved. With drills it is possible to see at a glance when blanks occur after the crop germinates; whereas in broadcast sowing such blanks are not easily noticed and hence the chance of resowing blanks is missed until it is too late.

Use of harrow after sowing.

In irrigated land, as pointed out above, the passing of the *sohaga* over the land after sowing is the final operation. As this implement is apt to leave the surface somewhat hard and shiny, it is very advisable to harrow lightly afterwards. For this the bar-harrow is eminently suitable. The light harrowing improves germination very visibly and prevents caking of the surface in case of subsequent showers of rain. The use of the harrow in this way for cotton is becoming widely appreciated in canal areas. Such harrowing only costs 4 to 6 *annas* an acre. This process is recommended particularly for general use in the case of cotton, and also for *toria*, wheat, and even sugarcane.

After cultivation.

Unless rain falls, when it may be advisable to harrow, nothing further is usually done until the seed has germinated and has about two leaves above ground in addition to the "cotyledon" leaves. Subsequent operations are described in the chapters dealing with the various crops. The main advantages of such after-cultivation or interculture (vernacular *godi karna*) is that it tends to maintain tilth. This tilth is obtained with great labour during the fallow and sowing time operations, and should be maintained as long as possible for the growing crop. Irrigation or rain tends to destroy it; also the lack of humus in the soil in the Punjab plains renders loss of tilth easy. By stirring the soil and breaking the crust after irrigation more air can also enter the soil, thus, helping in the formation of plant food and keeping the roots healthy. This interculture is especially necessary in the case of cotton, for which preliminary cultivation, as compared to wheat, is generally very hurried and short. Further, the mulch formed by interculture prevents excessive evaporation of moisture and saves watering, or enables the farmer to delay watering without injuring the crop. Delaying the first watering is often very important as by this means the roots are encouraged to go deep into the soil instead of concentrating at the surface. Once the roots get well down the crop is protected to a large extent from suffering by subsequent drought.

Another great advantage of interculture is that it helps to keep down weeds, especially in the summer season. A crop like cotton is particularly sensitive in this respect, and wherever much grass, such as *dub*, is allowed to grow with it, the yield suffers very seriously. The condition of some of the cotton fields, particularly in parts of the colonies, shows what a large field for improvement there is in this direction. Hand labour is too expensive, and reliance must be placed on bullock power, for the use of which sowing in lines is a necessary preliminary.

Harrowing.

After-cultivation may consist of harrowing, whereby the whole field is covered irrespective of the position of the plants. This is only feasible with small plants or in the younger stages of the growth of plants like cotton. Wheat, sugarcane and maize can generally be harrowed till the plants are from 6 inches to a foot above ground. Harrowing can be done in broadcast as well as line-sown fields. In the case of crops sown some distance apart, *e.g.*, cotton, sugarcane, maize, etc., the after-cultivation in later stages is done by implements drawn between the lines. Such implements are the "horse-hoe" and "Lyallpur hoe", the use of which is spreading satisfactorily. Hand implements used for this purpose are the ***khurpa***, ***kasola*** and the ***baguri***. Sometimes the country plough is also used (see Chapter VI).

References.

(1) "Physics of Agriculture", by King.

(2) Pusa Bulletin No. 51 of 1916, by Howard.

(3) Department of Agriculture, Punjab, Leaflet No. 160.

CHAPTER VI

AGRICULTURAL IMPLEMENTS AND MACHINERY

Costs of bullock and manual cultivation.

The working of different implements is explained in the chapter on cultivation. In addition, if we are to study methods of cultivation intelligently we must first arrive at some basis for ascertaining the costs of different operations as well as, the cost of the implements used. The cost of purchasing implements is not in danger of being overlooked in India, but it is sometimes suggested that it is not necessary to pay much attention to the cost of carrying out the various operations, since wages are very seldom paid; or when given are not paid in money and very little cattle food is bought by the farmer. Unless, however, some definite and fairly accurate figure is used as the price of a day's work by bullocks or men, it is impossible to proceed far in the systematic study of Agriculture. How are we to estimate the advantages or otherwise of using a bullock-drawn implement as compared to using manual labour for the same work or compare the relative advantages or disadvantages of two implements designed for carrying out the same operation ? How are we to compare the relative profits from different crops unless we can put in figures—not only the respective returns from their sale but also the relative amounts of labour; material, water and cash expended in their production. The gross returns from an average acre of sugarcane may be Rs. 300 per acre and of wheat Rs. 100 per acre. But it would not be true to state that sugarcane is thrice as profitable as wheat. Much more labour, both manual and bullock, more manure and more water have to be expended to produce sugarcane than wheat. Besides, sugarcane occupies the land longer, requires more fertile soil and bears a higher water rate. The making of *gur* takes nearly all labour available in

December and January. It is, therefore, only by expressing all these factors in figures that we can hope to be able to compute the cost of growing crops and thus lay the foundation for the comparison of relative profits or advantages of various crops.

Difficulty of estimating.

It is exceedingly difficult to fix accurately the cost to the farmer of a day's work by his pair of bullocks. Practically every figure used in the calculation has to be estimated. The bullocks are probably homebred not bought; they may live a comparatively long life or die young from accident or disease; the food is generally home produced by use of his bullock labour on his own land. Again, the value of fodders in a village depends on its situation, for fodder near a town and on a main road is more valuable than fodder at a distance from town or road. The value of the dung is difficult to estimate as it depends on the food consumed, the age of the animal and on the location as in the case of fodders. Moreover, practically, all these figures vary not only from place to place but from season to season and year to year. A similar difficulty is experienced in fixing the sum for the daily wage of a man. It depends on the time of year and the location. Again, the majority of farmers in the Punjab perform their own farm work and do not engage hired labour. We have to adopt a figure for general use based on all the facts as we know them. Taking all these factors into consideration we may assume, that prior to 1939 the charges for a pair of bullocks for a day at Re. 1/- is fairly satisfactory and 5 annas as the wages of a day's labour whether by a hired man or the tenant. These figures have to be modified for special purposes as, for instance, in harvesting wheat when labour is scarce, or in sugarcane crushing when there is little other work available for bullocks, or near large towns where labour and bullocks can find other outlets. Fortunately, as we are mainly interested in comparisons and not so much in absolutes, the variations do not matter so much. If the figures adopted are nearly correct and the same figures are used on both sides of the comparison, no great error in conclusions need be feared. It is, however, easy to criticise these figures and, therefore, the source and basis from which they are drawn will be given below.

Based on actual records, cost account of 144 holdings in three districts of the Punjab were maintained for 3 years (1933-34 to 1935-36) and were published in a report by the Imperial Council of Agricultural Research in 1938.

Figures given in this publication show that the cost of a pair of bullocks per working day was Rs. 1-0-6 for holdings in the Lyallpur District and Rs. 1-2-0, and Re. 0-14-9 for Jullundur and Gurdaspur districts respectively. As an average figure we have, therefore, adopted Re. 1 as the price of a pair of bullocks per working day. Similarly, for manual labour the prevailing rate of agricultural wages for permanent labourers as shown in this report varies from Re. 0-3-0 to Re. 0-5-6 per man per day. In Farm Account 1936-37* wages of the permanent hired labourers and the earnings of the tenants at the Risalewala Farm during the decennium ending 1936-37, are shown as under:—

Year	Per Day.	
	Wages of the hired labour	Earnings of a farmer's family member
	Rs. a. p.	Rs. a. p.
1927-28	0 5 11	0 6 8
1928-29	0 5 9	0 8 10
1929-30	0 5 6	0 5 9
1930-31	0 3 6	0 0 9
1931-32	0 4 2	0 3 0
1932-33	0 4 10	0 5 5
1933-34	0 3 11	0 3 7
1934-35	0 3 11	0 5 2
1935-36	0 4 0	0 6 7
1936-37	0 4 8	0 5 1

The average of these figures for the period of 10 years comes to Re. 0-4-7 and Re. 0-5-1 respectively. Accordingly we have adopted five annas as the average wage rate.

*In Loc. Cit. Page 17.

We can now proceed to discuss the implements themselves. Various agricultural implements and machinery may be studied in the following order :

Classification.

(1) Ploughs.
(2) Cultivators, horse hoes, and harrows.
(3) *Sohagas*, rollers, and *karah.*
(4) Drills.
(5) Reapers and binders.
(6) Threshers and winnowers.
(7) Fodder cutters.
(8) Cane crushers.
(9) Tractor and *tractor implements.*
(10) Carts.
(11) Yokes.
(12) Hand tools.

Persian wheel and other devices for lifting water from subsoil for irrigation purposes will be dealt with in chapter on "irrigation".

The Plough.

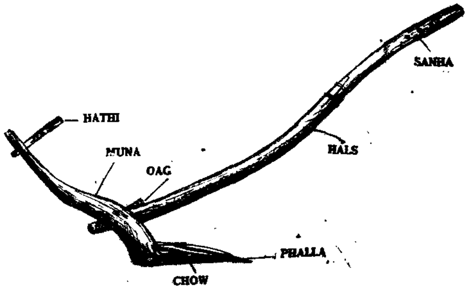
The most important agricultural implement is generally the plough and it will be convenient first to consider the country *munah* and *hal* (see figures 1 & 2) since these words are generally translated into English as 'plough'. And it is from somewhat similar wooden 'plough' used with bullocks that the modern horse-drawn Western ploughs have developed, though the Western plough as now known (see fig. 3) is very different. In fact, the Western heavy harrow or 'cultivator' does work more resembling that of the *munah* or *hal.*

Functions of a plough.

The functions of the modern plough, which are generally regarded as the most essential, are cutting off the layer of soil from the subsoil below, inverting it so as to bring the lower part to the top. Although some modern ploughs (such as introduced into this country) do also break the soil to some extent; this is not always the case and this is not regarded as an essential part of the duties of the plough. Moreover, though the depth can be varied to some extent, the iron plough is used to cut down to full depth at once and not adapted to work very shallow, if the soil is hard. Harrows and cultivators can be used for shallow work if necessary and the stirring and breaking up of the soil are their most important functions; they are not so efficient in cutting off the soil completely from the lower layers or in turning it over. The country plough is most efficient for stirring the soil and breaking it up ; it is not very effective in cutting the top layer of the soil and it does not entirely invert all the soil it loosens. It can be used to scratch to a small depth a soil which is too hard to plough properly.

Work of Indigenous ploughs.

The essential part of the native plough (*chow* in *munah*; *kur* in *hal*) consists of a tapering triangular block of hard wood (commonly *kikar* wood) with the base of the triangle uppermost. The point at the forward end is protected by a pointed iron "share" known as *phalla* (see figs. 1 and 2). In the case of the plough used in the Ambala District (known as *Nag hal*) *chow* is protected by iron pieces and in place of *phala* a long pointed iron bar is fitted so that it can be pushed forward if desired.



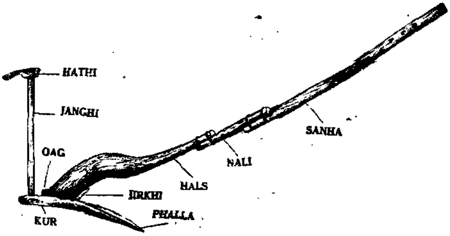
MUNA PLOUGH

Fig. 1.

As the plough moves forward, the *chow* being inclined downward, is forced into the soil and tears out a V-shaped groove or furrow in much the same way as a wedge cuts into a plank. The expanding sides behind the point partially turn the loosened soil over and also break the earth at the sides. Earth being friable, the furrow is not cut exactly in a V shape but is broken to some distance on both sides of the furrow. But, as the *chow* is narrower below than above, some earth is always left untouched between the furrows, so that if the loosened earth is swept off, the surface of the hard earth beneath is corrugated or wavy. The other parts of the plough in the case of *munah* are :—

	Hals	............or	............beam;
	Munah	............or	............body;
	Hathi	............or	............handle;
and	*Og* or *phana*	....or	............wedge.

The country plough is usually worked from right to left and the stirring of a field is accomplished by taking small strips of land called *rahals*. On an average the bullocks and the ploughman travel over a distance of about 12 miles in order to plough an acre of land.



HAL
Fig. 2.

It will thus be seen that the function of the share is to cut off the "furrow slice" of the soil by a horizontal and a vertical cut, and that it is so shaped as to do this as easily as possible. The 'mould-board' turns over the slice so cut to the right and in so doing also shifts it to the right. The 'mould-board' and 'share' are always made as two separate parts; this is because the 'share', doing the cutting work, gets worn out much more rapidly than the 'mould board' and requires to be replaced oftener than the latter. For the same reason the point of the 'share' is also frequently made separate from the remainder, so that the whole share need not be replaced when the point has worn out.

Other parts of the iron plough.

The other parts of the plough serve, as it were, as a frame to hold the share and mould board so that it can be pulled by bullocks. The lower surface of the landslide known as the sole (fig. 3) serves to support the plough horizontally on the ground and its side takes the pressure against the unploughed earth. The functions of the body, beam, and handles are obvious. The nozzle and hake serve to regulate the depth and width of the furrow by altering the point of attachment of the draft chain. Raising the point of attachment in the nozzle, tilts the front of the plough down into the soil and makes it run deeper while lowering it makes it run shallow; shifting attachment in the hake in the same way alters the direction in the horizontal plane; moving the attachment to the right, points the plough to the left, making it cut a wider furrow while moving it to the left has exactly the opposite effect. The change in the width of the furrow can also be made by adjusting the beam on the beam stay. If the beam is moved towards the right hand handle, the width of the furrow is decreased, whereas, if it is moved towards the left side, the width is increased. The function of the wheel is not that of regulating the depth of the furrow as is commonly understood, but it is adjusted according to the depth of the furrow as arranged by nozzle and other adjustments, so as to stabilize the plough and keep the depth uniform, throughout the field.

Draft of the ploughs.

The average comparative drafts of three most important or popular iron ploughs and *munha* are given below :—

Plough	Furrow	Total draft.	Draft per square inch of the cross section of the furrow.
		lbs.	lbs.
Rajah	6″ × 9″	170	3 15
Hindustan	6″ × 9″	153	2·83
Meston	5″ × 7½″	120	3·20
Munah	4½″ × 9″	130	6·42

It will be observed from these figures that the total draft of *munah* is less than that of Rajah or Hindustan, but its draft per square inch of the cross section of the furrow is more than double of what it is in the case of any of the furrow turning ploughs. The higher efficiency of the iron ploughs is due to the smoothness and sharpness of iron. It may also be noted that these figures relate to soil in *vatar* condition, but as the soil dries, the draft increases. In the case of *desi* plough, however, the draft increases much more rapidly than with the iron plough. This is as expected, for the cutting action of the latter facilitates ploughing in hard soil.

Advantages of furrow turning ploughs.

There are four main advantages of furrow turning ploughs :—

(1) They cut rectangular furrows and thus leave no land uncut between the adjacent furrows as is the case with indigenous ploughs. Thus, land, when ploughed once with a furrow turning plough, is prepared much better than with one ploughing by *munah* or *desi hal.*

(2) These ploughs cut and invert the soil, thus bringing the lower layer of the soil up and taking the top portion down, which is not possible in case of *desi* ploughs. Inversion of the soil also brings up the grubs of insects which are eaten up by birds.

(3) They pulverize the soil to a greater extent than *desi* plough does.

(4) Iron ploughs are very useful in weedy lands, for they uproot and bury the weeds in the soil which ultimately decay. They are particularly helpful in the eradication of deep-rooted weeds such as *kahi*, *baru*, etc., which of course must be removed and dried ; otherwise they are likely to establish again.

Difficulties with iron ploughs.

In the first place the iron plough with short beam as the Rajah is not so easy to control in some respects as the *munah*. The cattle are farther away from the ploughman and reins as well as long stick is necessary when working with them.

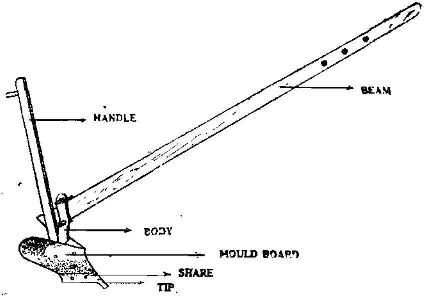
Secondly, owing to an open furrow being left at the end of ploughing the land is apt to get unlevel, a very important objection in irrigated land. This can be corrected to some extent by ploughing alternatively from the sides and the centre of the field. When starting from the centre it is useful to make an opening. In order to do this, at first a shallow furrow is made in the middle of the field. By turning the bullocks to the *left* the second furrow slice is cut at a distance of about 1½ feet from the first furrow. The uncut portion between the two furrows is then cut by two more furrows. The four furrows when finished leave a shallow ditch with two furrow slices on each side. These are then turned in towards the ditch by working the bullocks from left to right. The depth is then increased and ploughing proceeds in the ordinary way. By following this method, there should be no high land in the middle. There will, however, be furrows at the two sides of the field and these can be filled by *sohaga* when levelling.

Thirdly, the initial cost and upkeep of an iron plough is higher than that of *munah*. Rajah No. 1 is not now available in the market. But Rajah No. 2 can be had in its place. It costs Rs. 33. The share costs Rs. 1-7 and the point Re. 0-7-0. The point wears out after doing 10 to 12 acres in sandy soil, share 25 to 30 acres and the mould board 250 to 300 acres. In the case of loamy soils the life is longer.

Fourthly, various adjustments of an iron plough are a bit complicated. But they are not beyond the understanding of the ordinary ploughman.

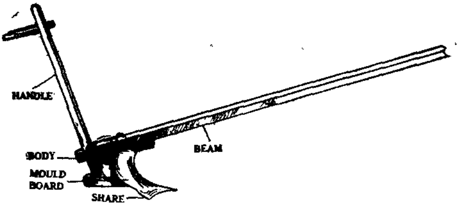
Iron ploughs recommended to the Punjab Farmers.

There are two types of iron plough—one having a short beam and the other a long beam. The short beam ploughs have a short beam and a land wheel. Important ploughs of this type are, Rajah, Punjab and Chhatanoga. These ploughs were introduced into the Punjab by the Agricultural Department about 40 years ago and were recommended for those possessing 50 acres or more. Mainly on account of their high cost, system of hitching the bullocks to them by means of chains, complicated nature of the method of regulating the depth and width of furrows, and difficulty in their repairs and securing spare parts, they never became popular in this province except in a few places where fields were infested with *dab* grass as in the case of certain parts of Gujranwala District. The second type of ploughs have a long beam and no wheel. Bullocks are yoked to them as in case of *munah*; consequently they can be easily controlled by the ploughman and are hence becoming very popular in the Punjab. These ploughs, however, do not run so steady as the wheeled ploughs. They can be further sub-divided into two classes —heavy and light. The heavy type includes Hindustan



HINDUSTAN PLOUGH
Fig. 4.

(Fig. 4) and Avery Hindustan.. The former can be had for Rs. 17-8 and the latter for Rs. 14 (iron parts). The light type longbeam ploughs are like heavy type but are smaller in size, lighter in weight and hence do not go so deep as the latter type. They are suitable for light lands and small bullocks. This type is popularly known as Meston plough. (Fig. 5). Many local artisans also make ploughs of this type, but the imported ploughs are better in workmanship and material and are consequently cheaper in the long run for they last much longer than those made locally. The price of the iron parts of the foreign Meston plough is Rs. 6-4, whilst the wooden beams and handle can be made locally. Its share costs 8 annas only and has to be replaced generally after doing 15 acres.



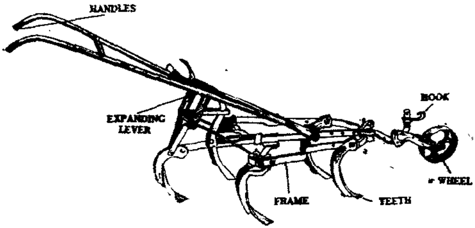
MESTON PLOUGH
Fig. 5.

Cultivators, horse hoes, and harrows.

Cultivators, horse hoes, and harrows of various sorts are implements with several or a number of teeth or tines affixed below some kind of frame intended for stirring the soil after first ploughing, breaking surface after rains, covering small seeds after sowing, and interculturing crops. They may primarily be divided into two classes —(*a*) heavier (*b*) lighter. The heavier implements work down to a considerable depth and have fairly broad points; they tear through considerable obstructions and can thus only be used on fallow land or between the rows of a crop. The lighter harrows, on the other hand, have many fine points. Owing to their light weight, they can be used on many crops (after they have been sown) without dislodging the seed or tearing up the plants.

Cultivators and "horse hoes."

The "horse hoes" recommended to farmers in the Punjab are adapted for use either on fallow land or between the plants of a crop sown in straight lines fairly wide apart; they are very useful for interculturing cotton sown in lines. Two men and a pair of bullocks can thus hoe 3 acres in a day. The width of the "horse hoe" can be varied from 18 inches to nearly 3 feet; and it can be adjusted fairly accurately according to the distance between the lines. These implements can also be fitted up as ridgers and used for making ridges. Two men and a pair of bullocks can ridge two acres in a day. Crops sown on ridges can also be intercultured with cultivators or hoes. When used on fallow lands or for after cultivation, a cultivator can stir 3 acres per day, which is three times the work of a *desi* plough.

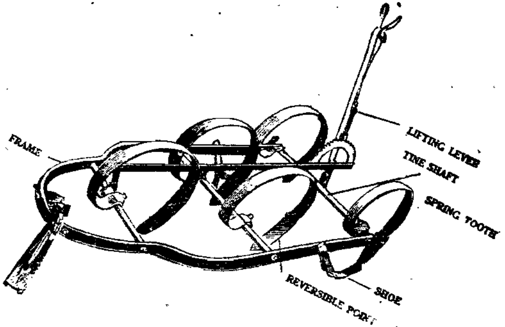


HORSE HOE
Fig. 6.

There are two makes of this implement available in the market at present: (1) The Planet Junior, and (2) The International Harvester Co. Cultivator. There are many types of these, but Planet Junior Plain Cultivator No. 101 and International Cultivator No. 53 are very suitable for a small farmer. The former costs Rs. 35 and the latter Rs. 30.

Spring-tined harrow.

The spring-tined harrows which have been recommended for use in the Punjab, are intended only for use on land on which no crop is growing. They cannot be used for cultivating between the plants of a wide-sown crop, for they cannot be directed with sufficient accuracy to avoid the plants and are also too wide. The springiness of the points is helpful, because when serious obstruction is encountered by one of the points or "tines", this one will bend without throwing the whole implement off its level and without breaking. The continual vibration of the tines also helps in breaking up the clods.



SPRING TINED HARROW
Fig. 7.

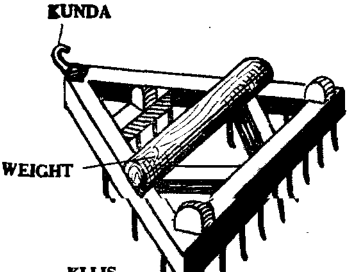
But the necessity for making the springs of good steel renders the implement distinctly expensive, and the expense of springs hardly appears necessary in the Punjab, where fields are commonly free from stones, rocks, roots of trees or other obstructions. Moreover, the springiness of the tines, prevents them from satisfactory tearing up a grass-like *dub* which grows in matted patches on the surface of the soil. There are two kinds of this implement sold in India: one with 5 tines and the other with 7 tines. The former can be had for Rs. 55-8 and the latter for Rs. 64-8.

Disc harrow. This implement consists of a frame carrying a number of saucer-shaped discs. The whole weight of the implement rests on these sharpened discs which cut through the soil, at the same time lifting and loosening it. For pulverizing ploughed land containing coarse stubbles like those of sugarcane, there is no more efficient implement than this. Its cost is, however, very high, *viz.*, Rs. 161.

Peg-tooth lever harrow. This is commonly used in U.S.A. The implement is wholly made of iron and strongly constructed. Its pegs can be sloped in any desired direction causing them to run deep or shallow. When the tines are pointing forward, it goes deep, loosens the soil and collects the weeds. When the tines are pointing backwards, it does not attain much depth but the soil is pulverized. In this position it is used for interculturing crops like wheat. The International peg-tooth harrow with 30 teeth costs Rs. 35.

Bar harrow.

This is a light harrow with 17 iron points, attached to a triangular wooden or iron frame. It was designed to replace the lever harrow just described. A similar implement is in common use in Madras and was adapted for the Punjab by one of the authors in 1918. The tines are made to point slightly backwards to avoid uprooting young growing plants as far as possible. Its width is 4 feet and it can cover 4 to 5 acres in a day of 8 hours. A piece of wood weighing about 12 seers is used to add extra weight whenever necessary. Bar Harrow is

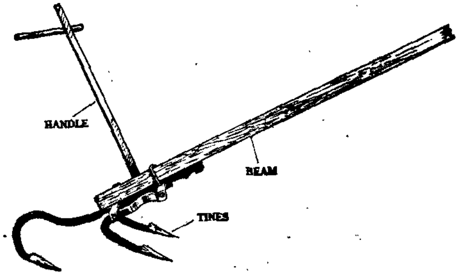


BAR HARROW
Fig. 8.

useful for harrowing any crop in its early stages, particularly wheat, cotton, toria, sugarcane, for breaking the crust after showers of rain and for producing a fine mulch immediately after sowing. In harrowing success depends largely on its being done at the right time, *i.e.*, as soon as the wheat is big enough or as soon as the soil is dry enough, as the case may be. It is usually better not to harrow whilst dew is still on the plants as wheat is then more liable to be uprooted. When harrowing after irrigation weight will be necessary, but for harrowing crops in early stages, immediately after sowing and breaking crust, weight need not be used. This implement can be obtained for Rs. 10-8 from the local officials of the Agricultural Department.

Lyallpur hoe.

This is a three-tined country-made hoe evolved at the Lyallpur Agricultural Farm. It has got a long beam and is pulled like *desi hal*. It



TARPHALI
Fig. 9.

can be used for the interculture of cotton sown in lines, and for breaking the crust which forms in fallow land after rain and irrigation. It can be had from the district staff of the Agricultural Department. Its iron parts cost Rs. 4, whereas complete hoe can be had for Rs. 5-2.

Advantages of cultivators and harrows.

It will be readily seen that it is much quicker and cheaper to work over a field with one of these implements than with a country plough, the saving being proportional to the width of soil covered at a time by the implement. Thus if it costs Rs. 1-5 to plough an acre with the country plough taking a 9-inch furrow, it will cost only about 7 *annas* to cultivate or harrow with an implement 2½ feet wide or if in hoeing cotton, it is necessary to pass the country plough two or three times between the lines of the plants, this will cost two or three times as much as hoeing with an implement which is wide enough to cover the whole area between the rows at one time. These implements obviously cannot be worked to such a great depth in a hard soil as can the country plough since they cover a much greater width. Nor do they, perhaps, turn the soil over or crumble it up so much as the country plough. But as will be seen in the next chapter, there are many occasions when the soil is not very hard, and it is not necessary to work very deep or to turn the soil over, and it is only necessary to loosen the soil, stir it and break down the soft clods. In such cases the horse hoe or heavy harrow can be used with great economy. An instance of this is after the use of the iron plough. Once ploughing moist land with an iron plough and two stirrings with a cultivator or heavy harrow will leave it in a much better condition than three ploughings with a country plough, and the cost will be considerably less. Again when a considerable area of land has been irrigated or rain has fallen, it is often very important to break up the surface of the soil quickly before it hardens again; it does not matter much if the work done is not very deep; the important point is that the whole area should be covered quickly. In such circumstances the profit from the use of a cultivator or heavy harrow may be considerable.

A 5-tined cultivator on an average stirs the soil up to a depth of 3 to 4 inches and in loamy soil its draft is 1½ to 1¾ cwts.

Sohaga and rollers.

For breaking clods both *sohagas* and rollers are used; but it is necessary to distinguish clearly between their effects, for there are very important differences in the action of these implements. If the work of a roller is observed, it will be seen that it compresses the soil and crushes any clods on it. This it does very effectively, for it is heavy and the weight all acts downwards on the small area of soil touching the bottom of the roller. But it does not, to any appreciable extent, shift any earth from one place to another. In so far as it levels the soil at all, it only does so by compressing the high parts more than the low and somewhat flattening out any elevations.

Work of the *sohaga*.

If the action of a *sohaga* be observed, it will be seen that it crushes clods to some extent, especially if weighted by labourers standing on it. This work, however, it does not do so efficiently as a roller. This is because the weight of the *sohaga* is spread over a large surface, and the pressure per square inch is, therefore, small. Thus a *sohaga* weighing 200 lbs. and with two men weighing 125 lbs. each on it, *i.e.*, 450 lbs. in all, exerts a pressure of 0·35 lb. per square inch only if the length is 9 feet and breadth 1 foot. In the case of a roller weighing 450 lbs. the surface in touch with the soil being much less than above pressure per square inch will be much more. On the other hand, the *sohaga* does what the roller does not, *i.e.*, levelling to a certain extent; for it definitely drags soil off the high parts of the land and leaves it in the lower parts. This action is very important on irrigated land which must be made as level as possible to allow of even irrigation; it also renders the *sohaga* a useful implement for covering seeds. It is not, however, so effective in breaking clods as the roller; also it should be noted that owing to its being dragged straight forward instead of rolling, the *sohaga* could not be used if it were as heavy as a roller and thus the effect of the *sohaga* in compressing the soil is not seen far below the surface as in the case of roller. Rolled land will be more solid below than similar land on which *sohaga* has been used.

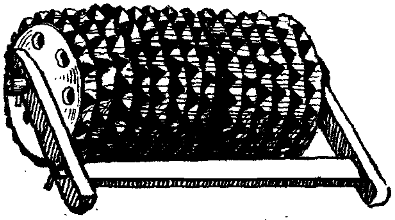
SOHAGA

Fig. 16.

There are two main types of *sohaga*. One of them consists of a thick wooden plank measuring 9′×1′×½′ and weighing about 2½ *maunds* and the other of 3 or 4 pieces of wood joined together with cross bars. The latter type is especially useful for breaking crust formed after rains and the clods. In some districts of the province *lappas* are fixed at the hindermost end of *sohaga* with their edges a bit protruding. This arrangement is very helpful in breaking clods. A small-sized *sohaga* known as *sohagi* is very commonly used in the Punjab. It weighs about 1½ *maunds*, measures 6′×10″×5″ and is worked with one pair of bullocks. A *sohagi* can cover 4 acres of land in a day as against 8 acres with *sohaga*. Their costs are Rs. 5-8 and Rs. 7 respectively.

Roller.

In the Punjab, roller is used only in a few districts, *viz*., Karnal, Rohtak, Muzaffargarh and D.G. Khan, where rainfall or irrigation water supply is insufficient or inadequate. In such areas, sometimes, it is necessary to compress the soil surface so as to draw up the soil moisture from below.



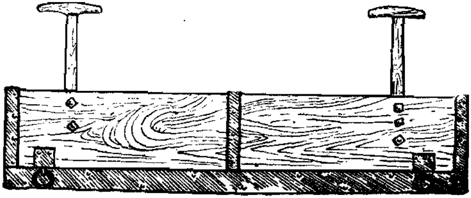
ROLLER
Fig. 11.

The roller used in our Province is entirely made of wood. It leaves the surface of soil smooth after it has been taken over it. In order to overcome this drawback there are several other forms of rollers too. Out of them Cambridge roller is the best (Fig. 11.)

In the working of rollers it must be kept in mind that their efficiency depends not only on their weight, length and diameter, but also on the condition of soil. If various tillage operations are carried out at proper time, the efficiency of the rollers is considerably increased. Once the clods have been formed in a soil, it should not be stirred again by a cultivator or country plough before irrigation, unless the clods have been crushed by roller. Otherwise the clods will be buried into the soft portion of the soil without breaking. In such cases it is only after giving another irrigation to land and by carrying out various tillage operations at the proper time that the texture of the soil can be improved.

Karah.

This implement simply consists of a wooden plank with adequate arrangement for hitching it behind the bullocks and for holding it by the workers. It is used for the levelling of uneven fields, especially when new land has been brought under cultivation or the level of fields has been very much disturbed. Like *sohaga* there are two types of *karah*. One is bigger and the other is small. The former is



KARAH

Fig. 12.

worked by two pairs of bullocks, whilst the latter by one pair of bullocks. While working it is kept in an upright position so that earth is dragged from the higher level to the lower places or depressions ; when going back to higher places it is kept in such a position that no earth is scrapped and carried with it.

"Drills" for sowing seed in two or more rows at a time were until recently unknown in the Punjab, though simple forms of drills have been used for centuries in some parts of India. Sowing by drills has many advantages. It saves time; in sowing wheat with drill having 3 tines, one man and a pair of bullocks can finish three acres in a day, whereas, by *pora* three times this labour is necessary. Through the saving of time the best use of the available moisture can be made. Another great advantage of the drills is that some of the crops like cotton and maize can be sown in lines with them. This makes it possible to carry out the interculturing operations properly by bullock-drawn implements. This again saves labour, time and moisture.

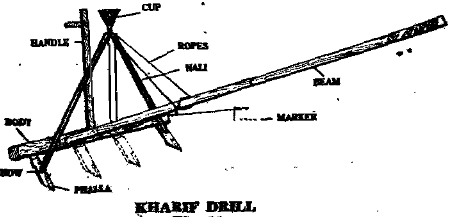
Drills.

From time to time automatic seed drills have been imported and tried for sowing various crops, particularly wheat and cotton. All of these had complicated mechanism and were very expensive. For this reason the Department of Agriculture at Lyallpur has evolved a number of simple drills for sowing most of the crops in the Punjab. They are briefly discussed below.

The "*kharif*" drill is suitable for sowing cotton. It differs from those used in other parts of India in the following respects :—

Kharif drill.

(*a*) metal tubes are used instead of bamboo and this applies also to *rabi* drill,
(*b*) metal cups are used instead of a wooden cup for the seed.
(c) A marker is attached to show the position of the next line.



KHARIF DRILL
Fig. 13.

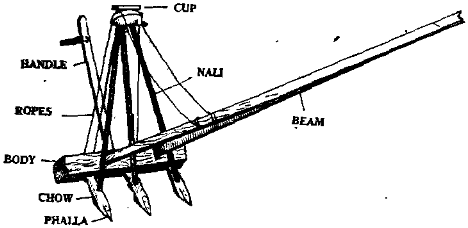
As a rule a long yoke (8 feet) is employed for the interculture of crops sown in lines with this drill. Such yokes are commonly used in Western India. The drill can be arranged to sow two lines at a time either two feet apart for *desi* cotton or 3 feet apart for American cotton. A marker is attached to the drill to mark a line where the next row is to be sown. The depth of sowing is controlled by the angle at which the tines are inclined to the soil, and this can be adjusted by altering the point of attachment on the pole or by means of wedges fitting the tines into the beam. When the bullocks are trained to the work, one man is only needed to drop the seed and to control the bullocks. In the beginning, however, two men are usually employed, one to drop the seed and the other to drive the bullocks. For this very reason, this drill has not become very popular among the farmers.

The drill should be worked straight up and down the fields and not round and round as is usual when sowing with the country plough. It is advisable to examine the bottom of the tubes at the end of the rows in the first few turns and occasionally afterwards, so as to see that tubes are not choked. In case of cotton the seed should be well rubbed over a *munj charpai* or hard floor and then leeped with moist soil or dung and dried before sowing.

The sowing of cotton in lines is to be strongly recommended. For, as will be seen later, cotton is a crop in which it is important to cultivate the land between the growing plants for several months. If the crop is sown broadcast, as is generally done in the Punjab, most of this work must be performed by hand labour at great expense; often it is not done at all. The seed can be distributed much more evenly and at a more regular depth by means of these drills than is at all possible by broadcast sowing in the case of thinly-sown crop like cotton.

Rabi drill.

This drill is meant for sowing *rabi* crops like wheat, barley or gram. It sows three lines 9 inches apart at a time and 3 to 4 acres can be sown in a day. The seed is dropped by hand into a wooden bowl from where it passes into the soil through 3 tubes. It can be used to sow any kind of seed the grain of which is not very large. But the seed must be cleaned of *ghundis* and straw specially in the case of gram. Since three rows are resown at a time, care should be taken that three times the amount of seed is used when sowing with the plough is dropped in the bowl.



RABI DRILL

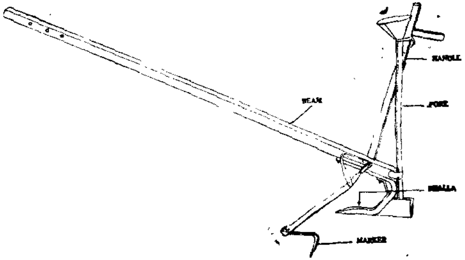
Fig. 14.

Both *Rabi* and *Kharif* drills are cheap and simple in construction. They can be easily made by any ordinary artisan and sample implements can be purchased from the local Agricultural Assistants or staff at Rs. 7-8 each.

The cost of sowing an acre by these drills, if two men are employed, may be reckoned at about 6 or 7 annas in the case of *desi* cotton or *rabi* crops.

Single row cotton drill.

The Department of Agriculture has recently evolved a single row cotton drill which is essenially similar to *munah* fitted with *por*. Its cost is Rs. 4 only, and on account of its easy handling and low



SINGLE ROW COTTON DRILL
(PORE HAL).
Fig. 15.

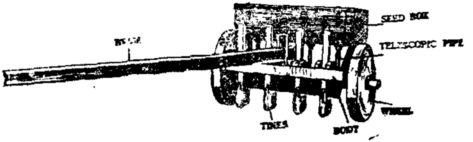
price it has been readily taken up by farmers in canal colonies and area under cotton sown in lines has considerably increased. This drill is now being manufactured locally as well as in several villages.

Hand Drill.

A single row hand drill for sowing cotton was evolved at the Lyallpur Farm. It is pulled by one man, while another controls it and drops the seed down the pipe into the soil. Germination obtained in the case of crop sown by this drill is much better than that by any other method of sowing. Though very eminently suitable for sowing small plots, it can be used on a field scale as well. But the only objection against the use of this drill is that of the substitution of bullock labour by manual labour. Its cost is Rs. 4 only.

Automatic *rabi* Drill.

It was designed by Mr. Johnston, late Deputy Director of Agriculture and has found limited success in the Province. This drill is suitable for the sowing of wheat and other similar-sized grains such as *chari*, *massar*, barley, etc. It is mainly constructed from wood and is so simple to work that any farmer can learn to use it in a short time. Besides beam and tines, its important parts are seed box, telescopic pipes, seed wheels, clutch-nut, axle-holder and driving wheels. Seed is put into the seed box from which it passes down through the telescopic pipes the length of which regulates the rate of sowing, into the lower box. When the pipes are shortened, more seed will enter into the lower box and the seed rate will be increased. There are two holes in the lower and upper pipe of the telescopic tubes. When these are opposite each other the drill will sow wheat at the rate of 24 *seers* per acre. From the lower box the seed wheels having notches bring up the seed and delivers it into tubes. Motion to the seed wheels is given by land wheels which roll on the soil as the bullocks move forward. The drill can be put into gear by means of clutch nut. If it is fixed on the axle, the seed wheels will work and if it is not fitted with the axle no motion will be transferred to the sowing mechanism. A device that prevents the axle from moving when the clutch is out of action is known as axle-holder. This should be used only when the drill is out of gear.



AUTOMATIC RABI DRILL

Fig. 16.

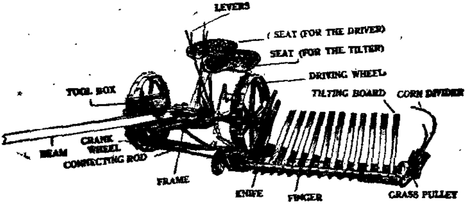
The drill sows four lines 8 inches apart at a time and a pair of bullocks can easily pull it. Only one man is required to operate it and 4 to 5 acres can be sown in a day. The cost of this drill is Rs. 37 and it can be obtained from the local agricultural officials.

Plough and marker. In addition to these drills, crops can be sown in lines at equal distance by using a "marker" on the *munah* or *hal* (see fig. 1). This method is recommended for those working on land not properly cleared, or where the labourers and cattle are untrained. The marker is easy to attach to *munah* and can be had from the local agricultural staff.

Reapers.

Owing to large area under wheat, labour during its harvesting season is much in demand and wages run higher than at any other time of the year. For this reason the Department of Agriculture has been trying to find and introduce into the province some economical methods of harvesting wheat or labour-saving harvesting machinery. The *datri* or sickle is almost invariably used for harvesting wheat throughout India. As long as labour is abundant and cheap this implement is very efficient. In Europe, the corresponding implement disappeared long ago. An effort was made to introduce scythe on the Lyallpur Farm, but it did not meet with any success (see chapter on wheat).

The first bullock-power reaper for cutting standing wheat, barley, and oats was obtained at the Lyallpur Farm in 1906. It never became popular with the farmers on account of its high price. Since then many other makes of reapers have been tried. Of these Hornsby No. 10 is considered to be the best. It has got a floating knife-bar, a feature that enables the reaper to pass over *bunds* or other obstructions easily. The price of reaper is Rs. 395.



REAPER

Fig. 17.

A strong pair of bullocks is required to work this machine since its draft is about 270 lbs. Owing to heavy draft frequent change of bullocks is also necessary. Eight men and two pairs of bullocks can cut 5 to 8 acres in a day. Of these, one man is required to control the bullocks, one man for raking, and the remaining six labourers remove the harvested crop from the path of the reaper, tie it into bundles and stack it. To start work a 5-feet wide path must be cut round the field by hand labour. During work, oiling of the machine and sharpening of the knives by carborundum file must be attended to regularly and frequently. This will also help in avoiding the choking of the machine which is likely to be caused by moist straw in the morning or heavy crop. Large farmers having 5 or more squares of land can economically cut their wheat with this machine. A number of small farmers can also work them on co-operative lines.

Self-delivery MacCormic reaper.

Self-delivery reapers differ from the manual delivery machines in that they collect, size and deliver the crop automatically. The main advantage of this type of reaper is that it discharges the harvested crop away from the path where bullocks are to come next time, so that the machine may continue working until the whole field is cut. With the ordinary reaper four men are required to clear the cut crop from the path of the machine so as to enable it to continue working. But the drawback of the self-delivery reaper is that it is more complicated. It is also not very flexible and requires much exertion to haul it over irrigation *bunds.* Its sizing and sweeping arrangement very often gives trouble.

This machine can be obtained for Rs. 452.

Self-binding reaper.

This machine cuts the crop, collects it, compresses it into bundles and ties them in one operation. It would require 3 pairs of bullocks to pull it, but since such a team would be very unwieldy to manage, it is worked by a tractor. Self-binder can most successfully be worked on large farms with fields above 5 acres. It can harvest one acre in one hour without difficulty.

The mechanism of this machine is quite simple. The crop is cut by knife and the harvested crop falls on the horizontal canvas platform. The canvas moves towards the centre of the machine carrying crop with it which is taken in by the two elevating canvasses. The crop is then left on the deck, where it slides down. Its downward movement is, however, checked by a lever, which does not release it unless the sheaf has achieved a proper weight and knot has been tied. A sheaf carrier may also be attached to collect a number of sheaves before they are finally delivered.

Cost of harvesting wheat by hand and by reapers.

For harvesting wheat by manual labour five men are required to finish an acre in a day. Usually they are paid in kind at the rate of one bundle each which yields about 16 seers grain and 28 *seers bhusa*. Thus, in all, 2 *maunds* of grain and 3½ *maunds* of *bhusa* are paid for harveting an acre of wheat. At the rates of Rs. 2-8 and Rs. C-8-0 per *maund* for grain and *bhusa* respectively the total cost by hand comes to Rs. 6-12.

By manual delivery reaper the cost will be as follows:—

	Rs.	a.	p.
Interest on Rs. 395 at 8 per cent. ..	31	10	0
Depreciation on Rs. 395 at 15 per cent ..	59	4	0
Repairs and oil	31	2	0
Labour:—			
Bullocks—2 pairs @ Re. 1 each for 14 days	28	0	0
Men— 8 @ Re. 1 each for 14 days	112	0	0
Total ..	262	0	0

Assuming 70 acres are cut in a season, the cost per acre comes to about Rs. 3-12. This means that by harvesting wheat with reaper, saving can be affected to an extent of Rs. 3 per acre. The cost by self-delivery is about Rs. 4 per acre, whereas that by scythe may be taken to be about Rs. 5-12 and by self-binder about Rs. 8.

Wheat is almost invariably threshed in the Punjab by the process of trampling by bullocks with *phalla* which is either made up of cotton sticks or *shisham* branches or *phalahi* sticks weighted with straw. But the *phala* made up of *phalahi* is the best because it is very efficient in rendering the straw into fine condition. Since the process of threshing by bullocks is very slow and tedious and it falls at the hottest and one of the busiest periods of the year, if some more speedy and economical method is found it will bring untold benefit to the farmers of the province. Moreover, the work of separating grain from *bhusa* may be held up due to absence of winds and threshed grain may be at the mercy of nature for days and even weeks. This is especially dangerous if the rains are early.

Threshers.

In order to evolve some suitable threshing machinery, the Punjab Agricultural Department has been carrying out some experiments on wheat threshing since 1907. About a dozen threshers have been tried but none of them has been found to be entirely suitable. Our experience here has shown that the problem of threshing wheat by machinery in the Punjab is not as easy as elsewhere. At the harvesting and threshing time the temperature is very high and weather dry; this causes the straw to become very brittle. When such stuff is fed into the thresher, it gets broken into fine pieces and chokes up the riddles of the machine thus reducing the output of the machine and making it uneconomical. The threshers also break a small percentage of grains specially in the morning which makes them more susceptible to attack of insectpests than otherwise Our problem is, therefore, to get over these difficulties and also thresh the crop satisfactorily, separate grain from straw, and make the straw into fine *bhusa*. The estimated cost of threshing wheat by bullocks and cleaning by hand at Lyallpur as shown later on under wheat is 6 annas per maund. If a machine could be obtained which would thresh at this rate or even a little higher, it would mean a great saving for large holdings. Small farmers cannot take up large threshers unless they are worked on co-operative basis. If collective forming is to be developed on Russian or other lines then this question will become a very live one.

So far four types of threshers have been tried: simple drum threshers; threshers containing drum and shakers; simple finishing threshers; and simple threshers with a device for making straw into *bhusa*. Of these only the fourth type fulfils the requirements of the Punjab farmer. The first type only extracts the grain from the ears. It is neither useful nor economical. The second type is a slight improvement over the first, but is not satisfactory. The third type, *i.e.*, simple finishing thresher is more successful. It separates the grain from straw and cleans the grain fairly well, but does not make *bhusa* and the output is low, about 6 to 8 maunds per hour. The low output is due to choking which could not be removed even after making structural alterations in the machines tried. Of the fourth type 2 makes were tried and their working was described in the Agricultural Journal of India, Vol. X, Part III, July 1915. The output of the 30″-wide machine was 4·62 *maunds*, whereas that of 48″-machine 12·74 *maunds* per hour. The quality of *bhusa* was good and the percentage of damaged grain was 2 to 5. These machines were not economical and lot of difficulty was experienced in moving them from place to place.

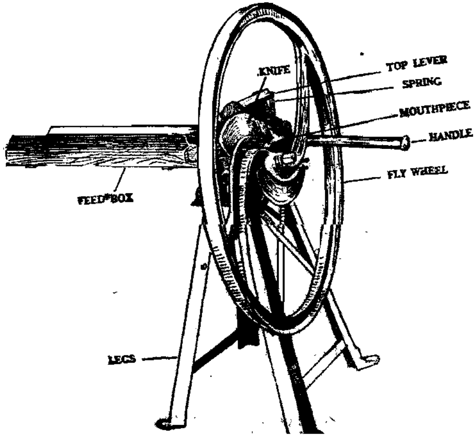
Winnowers.

The evolution of a winnower suitable for separating grain from *bhusa* is of considerable importance to the province. The ordinary *chhaj* which is commonly used is quite suitable for the purpose, but when winds fail it is of no use. With a view to designing a suitable winnower, some experimental work has been done at Lyallpur. It seems that a machine containing fan and a few riddles should serve the purpose well. Since wood does not stand our hot climatic conditions, the Agricultural Engineer constructed a machine mainly made of iron, but this was found to be too heavy. (See Wheat for further details).

Several types of the ordinary winnowers for giving a final cleaning to grain have been tried at the Lyallpur Farm. All of these worked quite satisfactorily and are recommended to farmers. Their price is rather high. The "Zamindar" winnowing machine costs Rs. 215.

Fodder Cutter.

Of all the improved implements introduced into the province, none has become so popular as the fodder cutter. It is due to the usefulness of the machine as against the drudgery of cutting fodder by a hand-*toka* that it has been readily taken up by farmers. It is no exaggeration to say that more than 100,000 fodder cutters are in use at present in this Province. The use of fodder cutter not only saves labour but also economises fodder as there is less wastage in feeding finely-cut fodder. The work that can be doue by a good hand-driven fodder cutter is equal to three times that of a hand-*toka*. Fodder cutters worked by bullocks are also available; they can chaff from 20 to 40 *maunds* of green fodder per hour. Those driven by mechanical power (oil engine or electricity) cut from 30 to 150 *maunds* per hour.

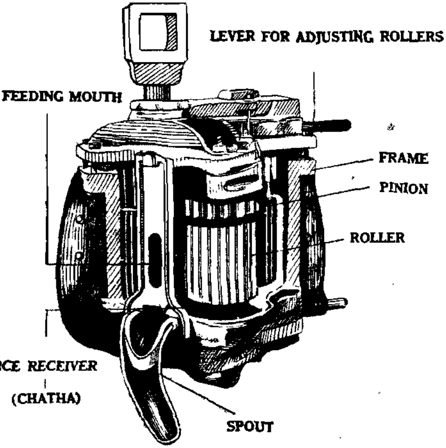


The first chaff cutter introduced was "Rajah" costing Rs. 64. Owing to its high price it did not become popular. The usefulness of such machines was, however, realized by everybody. This led many manufacturers to make cheap fodder cutters locally. They have been readily taken up by farmers and at present a very large number of them are being manufactured in the Punjab, especially at Batala, Goraya, Okara and Lyallpur. These machines do equally good work as the imported ones, but their material and workmanship require improvement. The output of hand machines varies from 6 to 8 maunds per hour. A list of those recommended is given in the "Punjab Farmer". Their output, prices and agents or manufacturers are also shown in the list in a tabular form.

Cane crushers.

The *belna* or cane-crushing mill is used to extract juice from canes. In early days it consisted mainly of wooden rollers, but now it has given place to iron rollers. From the *katha* cane the old wooden *belna*-extracted juice only to an extent of 40 per cent. of cane weight, the modern iron cane mills give an extraction of 50 to 65 per cent.

There are several types of iron mills on the market. Broadly speaking they can all be divided into two classes : (1) bullock-driven mills; and (2) power-driven mills. Of the bullock-driven mills tried so far the Nahan Sultan has been found to be the most efficient and the best constructed. It consists of three rollers grooved vertically and gives an extraction of 56 to 65 per cent. Its output is about 3½ *maunds* of cane per hour. It can be had for Rs. 135.



CANE CRUSHER
Fig. 19.

Cheap types of bullock-driven mills are also manufactured at Batala. Their price varies from Rs. 50 to Rs. 80, output is about 3 *maunds* per hour and extraction is 53 to 60 per cent.

Of the power-driven mills only Chattanooga No. 192 and Massey 14″ × 10″ have been tried at Lyallpur. Both of these mills gave the same output *viz.*, about 30 *maunds* canes per hour and are quite satisfactory. They are recommended to farmers. Both of them require a driving power from 10—15 H. P. Particulars for various cane-crushing mills, as regards weight of juice extracted per 100 *maunds* of cane, output, price, etc. are given below :

Name	Weight of juice extracted per 100 mds. of cane.	Output of cane per hour.	Price.	Agents.
	Mds.	*Mds.*	Rs. a. p.	
Nahan Sultan	50—65	2.4 to 4.	135 0 0	Nahan Foundry District Ambala.
Batala	53—60	2.4 to 3.6	50 0 0 to 80 0 0	Batala, District Gurdaspur.
Elephant	51—56	1.8 to 2.0	120 0 0	Messrs. Burn and Company, Howrah.
Chattanooga bullock-driven, No. 112.	59—65	3 to 6.	197 0 0	Messrs. Volkart Bros., Lahore and Karachi.
Chattanooga bullock-driven No. 122	53—60	3.2 to 3.7	262 8 0	do.
6 H. P. Chattanooga, No. 144.	55—64	9.5 to 12.4	681 12 0	do.
10 H. P. Chattanooga, No. 145.	60—64	20 to 25	914 0 0	do.
15 H. P. Chattanooga, No. 192.	60	25 to 28	1,464 0 0	do.
Belt Power attachment for No. 122 bullock-driven Mill.	..	..	224 0 0	Messrs. Volkart Bros., Lahore.
Bagasse Carrier for No. 192.	..	..	101 0 0	do.
Juice Pump for No. 192	..	..	157 0 0	do.
Bagasse Carrier for No. 145.	..	..	73 0 0	do.
Juice pump for No. 145	..	..	142 0 0	do.
Local Cane Mills	..	..	50 0 0 to 80 0 0	Lahore, Lyallpur and Batala.
"Massey" 10″—14″, Cane Crushing Mill.	..	25 to 30	1,700 0 0	Empire Engineering Co., Cawnpore.
Karamat Sugarcane Crusher.	..	2.95 to 5	190 0 0	Messrs. Kirloskar Bros., Ltd., Kirloskar Vadi, District Satara.

Tractors. The Department of Agriculture, Punjab, has been conducting investigations on tractors and tractor implements at Lyallpur for over two decades. In 1920 two motor tractors were purchased—an Austin and a Cletrac, each 19-20 H. P. The first one was of the ordinary wheeled type, whilst the second was of the caterpillar type. The working and ~~costs of performing~~ various operations by these machines were studied thoroughly. Neither of them was found to be reliable because they continually developed mechanical troubles of various types. Their chief drawback was that they had not got sufficient power to pull a 3-furrow plough and ran hot for greater part of the year. Excessive wear and tear resulted from their continued overheating and other causes. In the case of Austin, the cost of spare parts worked out to Rs. 2-1-6 per hour, whereas, in the case of Cletrac, owing to high wear and tear of the chain track, it was Rs. 5-12. They were, therefore, discarded. Of these two types, Cletrac was more suitable for cultivation as it can be easily manipulated and turn in its own length. Its chain track gives a better grip, but the position of its pulley renders it unsuitable for stationary work.

As a result of experience with these machines, high powered tractors were tried *viz.*, 18—32 H. P. Case and 65 H. P. Sentinel Steam Tractor. The latter was bought with the idea that steam engine might prove more reliable and less troublesome than internal combustion engine. The "Case" proved to be more reliable and economical than other tractors. When it had finished 1,133 hours work, its running cost per hour was Rs. 1-13. The Sentinel Tractor was of unusual type. It had caterpillar driving tracks behind, steering wheels and boiler in front, and propelling mechanism behind. The steam pressure was very difficult to maintain, steering was unsatisfactory and the time required to refuel and secure water was uneconomical and it was, therefore, discarded.

In 1928 a MacCormick Deering 15-30 H. P. was obtained. This proved to be the most reliable and economical tractor. Expenditure on its spare parts for the first 934 hours, work amounted to only 8 pies per hour.

The foregoing account of the trials of tractors in the Punjab indicates that early experience with tractors was not satisfactory as the tractors then available in the market were light powered and not of desirable type. The same was the experience in the Western countries. The tendency nowadays is to use high-powered tractors (25 to 95 draw-bar Horse Power).

There are two different types of tractors : (*a*) wheeled tractors; and (*b*) caterpillar, crawler or track tractors. Wheeled types with steel wheels and spuds are suited for heavy field work such as ploughing, heavy harrowing and other slow speed farm operations and with pneumatic tyres for lighter farm operations such as sowing, light cultivation work, light inter-culture work and farm haulage. They are also very well suited for stationary work. The caterpillar type develop great draw-bar pulls required for deep tillage in difficult soils. They are likewise capable of operating in loose and moist soils successfully when wheeled types are unable to work on account of slipping. On large farms where more than one tractor is needed a combination of wheeled and caterpillar types is useful, so as to use each for only those operations for which it is most suited, in order to secure maximum efficiency.

Other points that should be considered while purchasing a tractor are reliability and low working cost. Tractors run on petrol and kerosine oil prove rather expensive, while those run on Deisel oil are less expensive. The latter should, therefore, be preferred. It is always advisable to deal with some reliable firms of long-standing which should be able to provide spares, and repair facilities at convenient places.

Possibilities for tractor cultivation.

The idea that tractors can replace bullocks entirely is wrong, for they are neither as reliable nor as economical as bullocks, on the ordinary cultivators' holdings. However, for initial breaking up of lands, for ploughing waste lands infested with weeds like *kahi baru*, *dub*, etc., for preliminary cultivation where labour is scarce, as a stand-by on large farms for augmenting the animal power in busy season, and for driving machinery such as fodder-cutters, threshers, grinding machines, etc., they are very useful.

Further, tractor ploughing is an economic proposition only when prices of agricultural produce are high and fields are fairly large sized. With wheat over Rs. 4 and cotton over Rs. 12 per *maund*, the use of tractors is more paying than bullocks. The length of field should preferably be not less than 1000 feet because longer the furrow better it is, since, time wasted on turning the tractor at the head of each furrow is reduced.

In some foreign countries such as Great Britain, U.S.A., Canada and Australia, tractors are being used on agricultural farms in thousands. Since the outbreak of war, to meet the scarcity of human labour, the use of tractors there has become quite common, and their number has increased considerably.

The estimated number of tractors in use in Great Britain in 1944 in comparison with that in 1942 is shown below :

Tractor	1942	1944
Track Laying—		
Agricultural	4,505	6,730
Market garden type	1,085	2,015
Three and four wheeled	104,780	153,085
Two-wheeled	6,455	10,940
Total ..	116,825	172,770

It may be observed from this table that the number of tractors in Great Britain is very large and that this number is on the increase. In the Punjab, with about the same area, the number of tractors used for agricultural purposes is negligible. It is, however, expected that with high agricultural prices in this country tractors will become more popular. In fact, tractors are already in great demand, but due to war conditions, export restrictions in U.S.A., and import restrictions in India, tractors are not easy to get these days. But under the Lend-Lease programme some tractors are being imported into this country in connection with 'Grow More Food' campaign. In order to get a tractor, therefore, the prospective purchasers are advised to get in touch with some reliable firms* dealing in tractors for forward delivery. After the import licensing authorities in India and the allocation authorities in U.S.A. have been satisfied that the equipment to be imported is absolutely essential the arrangement for the supply of tractors is made. At present some tractors under this arrangement have already been imported into this country and are being worked for agricultural purposes. In U.P. the Department of Agriculture is letting out two caterpillar Deisel tractors to landholders for the cultivation of their lands, mostly for breaking up virgin lands. The charges, including cost of material, wages of the staff, depreciation and repairs and interest on the capital cost of machinery are worked out in each case, since they are liable to vary with the type of soil and depth of ploughing. On an average, they may be taken, as follows:

Operation.	Work done per acre 10 hours.	Cost per acre nowadays.	Cost per acre before war.
	acres	Rs. a. p.	Rs. a. p.
Ploughing 12"-deep in "*Kans*" infested hard soil	3.5	25 0 0	15 13 6
Ploughing 6"-8" deep (*banjar*) or cultivated land	5.0	14 12 0	9 6 0
Harrowing	17.1	4 5 0	2 12 0

On sugar factory farms, the cost works out to be Rs. 11-2-6 to Rs. 11-10-3, as against pre-war cost of Rs. 6-14 to Rs. 7-3-9. Similarly, in Sindh the charges fixed for tractor ploughing are Rs. 12-8 per acre.

Besides type of work and type of soil, the operating costs of tractors are liable to variation according to their type and power. Taking 10,000 hours as the working life of a tractor, the total expenses (out of pocket and overhead costs) vary from Rs. 3-8 to Rs. 11-8 for caterpillar Deisel tractors with draw-bar Horse Power ranging from 25 to 95.

*Volkart Brothers, and (2) Buckwell & Co.

It is quite possible that in the past trials, the tractors were given tasks that were too severe for them. In the United Kingdom since the war a low-powered tractor, such as the "Trusty" of only 6 H. P. has become very popular. Such a tractor should only be used for one furrow plough and with small harrows and disc harrows. It would only be suitable for ***dab*** and *kans* eradication with special light implements. The small Tractor of 6 H. P. would be suitable for an area of 2 squares or 50 acres, and could be used for driving fodder-cutters, cane-crushers, pumping, haulage (1½ tons only) and various similar jobs. The initial cost is low and manipulation easy. Very little is known in India of the work of these small tractors, but there appears to be a good future for them.

Prospect of low power tractors.

When the tractor cultivation was first started at Lyallpur, a certain number of implements were purchased on the recommendation of the agents or manufacturers. Since then they have been thoroughly tried and many others besides. The working of various tractor implements is given below:

Tractor implements.

There are two kinds of ploughs: mould board and disc. The former is older and is only an enlarged form of a furrow turning plough such as Rajah plough. Instead of one share, two, three or four shares are fitted on a frame, and the whole is pulled as a unit. The number of shares a plough should have depends upon the power of the tractor and type of soil. For most Punjab soils three-furrow plough is quite suitable. The disc plough instead of shares has two to four saucer-shaped discs each about 24" in diameter. It disturbs the level of land more than mould-board plough, but pulverizes the soil better and is more suited to rough land and stiff soil.

Tractor ploughs.

For tractor work a plough should be of the self-lift type, as it saves the labour of one man. Ploughs of this type can be worked by the man driving the tractor and can be lowered into or raised from the ground without stopping the tractor. Three ploughs of self-lift type have been found to be quite suitable for the Punjab soils. One is three-furrow plough of American origin. Another is the two-furrow plough; manufactured in the United Kingdom. It can plough 0·57 acres as against 0.8 acres per hour with three-furrow plough. The third is the five-disc plough.

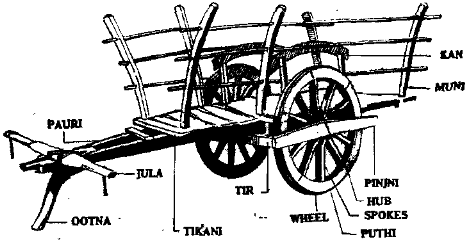
Tractor cultivator. These implements have 10 to 20 tines and the work done much resembles that of a "*desi hal*". It is an economical implement for stirring up fallow lands. A Ransome cultivator with 11 tines can be had for Rs. 510. It can cover about two acres of land in an hour.

Tractor disc harrows. These are of two types, some having only one row of discs and others having two rows. In the case of two-rowed disc harrow, the front row disturbs the level and the second row counteracts it. Disc harrows should, therefore, be of the second type, *i.e.*, with two rows of discs. They are very useful on heavy lands or on those infested with weeds. It is the most effective pulverizing implement yet introduced. Tandem Disc Harrow (32 discs) can be had for Rs. 556-12. It can stir soil at the rate of 2 acres per hour.

Tractor spring tooth harrows. These are very economical particularly on light soils and are useful for breaking down lumps of soils to get a fine tilth. Their use is strongly recommended. By combining several bullock spring-tined harrows their size can be made to suit tractors of any power.

Carts. Carts are very extensively used in the Punjab for transporting agricultural produce from rural areas to markets and for carting manure. Their greatest number is found in Ferozepore and South Eastern districts of the Punjab. In the North-Western parts the number is very small because of the lack of roads. In these tracts camels and donkeys are used. The cost of transport by camels is nearly twice the cost by bullocks. In 1940 there were 329,320 carts in the Punjab, whereas, in 1909 the number was only 281,000. The rise in the number of carts indicates a tendency to abandon pack animals for carts. This is largely due to steady increase in the mileage of roads.

Essentially a *cart* consists of wooden framework supported on two wheels (see fig. 20). The frame is broad at the back and narrow in front. In order to prevent the material transported from falling off the cart, various forms of devices are used. The weight of a cart is about 14 *maunds* and its price about Rs. 80.



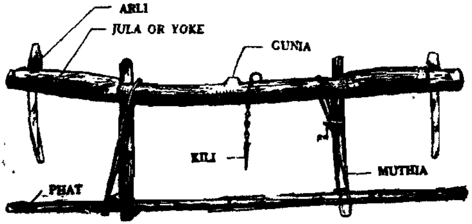
CART
Fig. 20.

Since the cart is the principal means of transport with the cultivator, efforts have been made to improve it by fitting it with pneumatic tyres. Tests made at Pusa showed that carts with Dunlop equipment were able to carry 55 *maunds* of sugarcane as against 25 maunds possible with ordinary countrycarts. Further, it is claimed these carts are 15 to 20 per cent. faster than the ordinary cart and they do much less damage to the road surface. It has been estimated by the Central P.W.D. that destructive effect of ordinary cart on roads amounts to Rs. 228 per year. There seems to be every reason, therefore, to encourage the use of carts fitted with pneumatic

The diameter of the wheel is of special importance in the cart. The larger the diameter the lower the draft and *vice versa*. Other factors, such as strength, sturdiness and cost limit the size. It must also be noted that for a cart fairly tall and heavy bullocks are preferable, for light bullocks cannot pull it efficiently. An average pair of bullocks can draw a weight of about 30 to 35 *maunds* on *kacha* roads and about 40 to 45 *maunds* on *pucca* roads.

Panjali or Yoke.

Panjali is used in nearly every farm operation when bullocks are used. It consists of *jula*, *phat*, *muthias* and *arlies*. *Jula* rests on the necks of bullocks, *muthias* connect the *jula* and *phat* and *arlis* prevent the bullocks from getting out of the *panjali*. In various parts of the Punjab the size and form of the



PANJALI
Fig. 21.

panjali used are different. According to size they can be divided into three types :

(1) *Short panjali.*—It is about 5 spans in length, *i.e.*, 3 feet 9 inches and is meant for *charsa* and circular track work such as persian-wheel, cane-crushing mill, *kharas* etc. It is of a smaller size so as to reduce the difference between the distances travelled by the right and left bullocks.

(2) *Ordinary panjali.*—It is 7 spans or 5 feet and 3 inches in length and is used for ordinary work like ploughing.

(3) *Long panjali.*—It is 8 feet in length and is used for hoeing cotton sown in lines.

The *panjali* of Hariana tract is merely a *jula* with small *muthias* and *arlis.* Leather straps or *jots* are used while working. The *panjali* of hilly tracts is also of this type, but thinner and smaller in length and size.

Hand tools.

There are numerous hand tools used by a Punjab farmer. To describe all of them in detail will occupy much space, accordingly only special points for important tools are shown in the following table.

HAND TOOLS

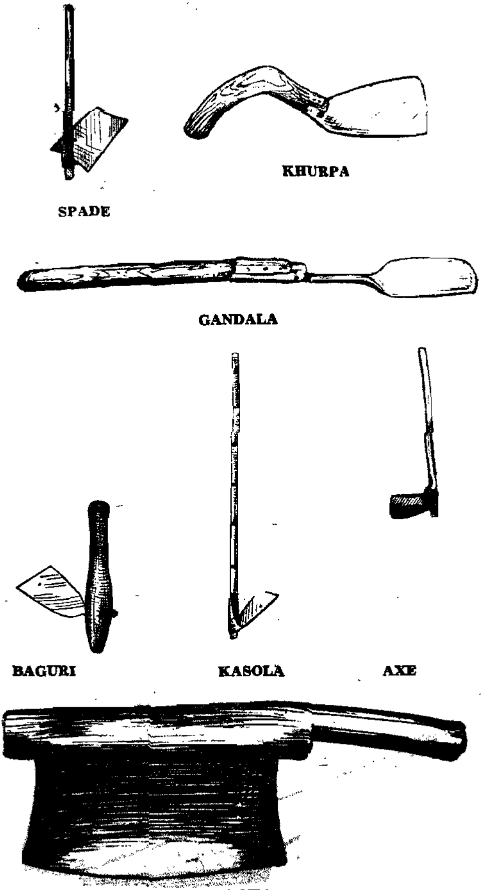


Fig. 22

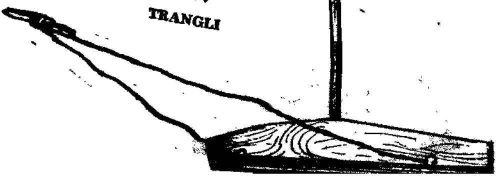
HAND TOOLS (*concluded*)

SICKLE

PILCHHI DATRI

SANGA

TRANGLI



Serial No.	Name.	Uses.	Standard of work per day.	Life.	Price.	REMARKS.
					Rs. a. p.	
1	Spade ..	Digging, making *bunds* and *khals* hoeing, levelling, cleaning of water channels, spreading manure etc.	One man can clean canal water channel 1100′ in length, hoe 1¼ *kanals*, make ridges in 2 kanals 2′ apart and spread manure in one acre.	3 to 4 years.	2 0 0	"*Gainti*" and "*belcha*" are modifications of spade, they are used for special purposes.
2	*Ramba* or *Khurpa*.	Hoeing, weeding, cutting grass and fodder, also sometimes for chaffing turnips and making sugarcane sets.	One man can hoe 2 *kanals*.	2 years.	0 6 0	*Khurpi* is a miniature *Khurpa* and generally used for the hoeing of nursery, garlic, onion, and other thickly-sown crops.
3	*Gandala* or *Chuha ramba*.	Digging holes in the soil for hedges and fences.	One man can make holes round one acre.	4 to 6 years.	0 6 0	In South Eastern Districts *sabul* is used.
4	*Baguri*.	Hoeing of sugarcane before germination.	One man can hoe 2 *kanals*.	4 years	0 6 0	*Khurpa* is used in place of *baguri* in some districts *e.g.* Ludhiana, Sialkot, etc.
5	*Kasola* and *Kasoli*.	Hoeing of cotton, maize, and sugarcane.	3 to 4 *kanals* with *Kasola*, 2 to 3 *kanals* with *Kasoli*.	4 years	1 8 0 & 1 4 0	In some districts *Khurpa* and spade are used for this purpose. *Kasoli* is used by *weak labourers* and children for hoeing cotton and sugarcane.
6	*Kulhari* or *Kuhari*	Used for cutting wood.		5 years	0 12 0	
7	*Gandasa* or *Toku*.	Chaffing fodder, cutting cotton sticks and sugarcane and making sets of sugarcane for sowing.	2 to 2½ *maunds* of fodder per hour	2 years	0 8 0 0 12 0	
8	*Phaura* and *Phauri* ..	Removing dung, sometimes used for levelling small beds, and for collecting grains when it is known as *Sabbar katta*. *Phauri* is used during *rauni* to assist the flow of water in beds and for making water muddy for sowing *senji*.		2 years 1 to 2 years	0 8 0 0 6 0	"*Phauri*" used for heaping grains in markets has iron blade.

Continued on next page.

HAND TOOLS USED BY A PUNJAB FARMER.

	Name	Uses.	Standard of work per day.	Life.	Price.	Remarks.
9	Hand Hoe with adjustment.	*Hoeing of vegetables and crops* on a *small* scale, ploughing small plots, scrapping weeds and making ridges.		5 to 6 years	25 0 0 35 0 0	Single or Double wheel. Can be had from Messrs. Volkart Bros., Lahore.
10	Sickle ..	Harvesting crops and weeding nursery or thickly-sown crops in some parts of the province.	2 kanals ..	3 to 4 years	0 8 0	
11	*Pilchhi datri*.	Stripping sugarcane.	4 to 9 *maunds*.	5 to 6 years	0 6 0	It is without teeth. In some districts ordinary *datri* is used in place of it.
12	*Jandra* ..	Making *bunds* and levelling small plots.	Two men can make *bunds* in four acres in canal-irrigated areas.	5 to 6 years	1 4 0	A *Jandra* having teeth is used for making *bunds* after sowing.
13	*Sanga* *trangli*	*Sanga* is used during threshing crops. *Trangli* is used in later stages of threshing and it is used for winnowing as well.		1 year 3 years	0 8 0 1 8 0 to 2 0 0	*Sanga*. *Trangli*.
14	*Karahi* and basket.	Used for carrying grain, *bhusa*, manures, fodders, etc.		3 to 4 years & 6 months	1 8 0 0 4 0	*Karahi*. Basket.
15	*Chhaj* ..	*Chhaj* is used for separating dust and weed seeds, etc., from grain and also for winnowing.		1 year	0 8 0	*Chhaj*.
16	*Poni* ..	For removing scum, etc. (when boiling juice).		4 to 5 years	0 8 0	
17	*Ghanwa*	For stirring *pat* (*Gur* making).		2 to 3 years.	0 4 0	
18	*Dora* ..	Used for transferring juice from one pan to the other.		4 to 5 years.	0 12 0	
19	*Thapi* ..	For stirring *pat* in *gand*.		3 years	0 1 0	

References.

(1) Farm Accounts in the Punjab (Board of Economic Inquiry publications).

(2) Report on the Cost of Production of Crops in the principal Sugarcane and Cotton-growing tracts in India, Vol. I, the Punjab, 1938—Imperial Council of Agricultural Research.

(3) Department of Agriculture, Punjab, leaflets Nos. 1, 2, 3, 4, 21 and 57.

(4) A Summary of more important results arrived at or indicated by the Agricultural Stations and Research Officers in the Punjab—1930-31 to 1934-35 and 1935-36 to 1937-38—Department of Agriculture, Punjab.

(5) Experiments at the Agricultural Farm, Lyallpur, Punjab—January 1930.

(6) Farm Implements & Machinery Review, May 1, 1945. (p. 48).

CHAPTER VII

FALLOWING, ROTATION, AND MANURING

It has been mentioned in Chapter IV that though crops remove fairly large quantities of nitrogen, phosphoric acid and potash, yet there is an abundance of these materials present in the soil to produce a large number of crops. As comparatively small proportion of these substances is in the available form, the yield of crops from soil, which is continuously cropped, decreases, and ultimately becomes uneconomical. It is, therefore, necessary that in order to maintain the yield, either the drain on the soil should be reduced by keeping it fallow and following proper rotations, or plant food to the soil in the form of manure should be added. All these three processes, *i.e.*, fallowing, rotation and manuring, being interconnected are difficult to discuss completely apart from one another, or from the main character of the agriculture of the tract, *i.e.*, whether *nehri* (canal) *chahi* (well) or *barani* (rain-fed) cultivation is prevalent. For the sake of clearness, however, it is necessary to attempt to discuss them separately.

Fallowing.

Fallow is a word of Saxon origin, meaning pale-yellow, and, therefore, when applied to farming suggests bare ground.* In the ordinary sense it means to leave the soil uncropped for some time so as to recoup its fertility by giving rest to the soil and by accumulating some nitrogen from the air. This becomes, therefore, partly a substitution for manuring. The fallow may be long as in the case of *barani* areas and short as in the case of irrigated areas. Long fallowing on *barani* lands is essential because manuring is little favoured in such areas on account of lack of adequate moisture required for the decomposition of organic matter.

* Bailliere's *Encyclopædia of Scientific Agriculture*, Vol. I, p. 293.

In sharp contrast to growing the same crop year after year rotation means the system of raising crops from a piece of land in such an order or succession that the fertility of land suffers the least and farmers' profits out of land are also not reduced. This system has been practised in India from times immemorial and every cultivator is quite familiar with it. The main advantages of a scientific rotation are.

Rotation.

(1) By rotating crops of different seasons it is easy to control the weeds. Some weeds are much more troublesome in summer than in winter and can be suppressed by growing *rabi* crops after summer fallowing. Similarly some crops like potatoes, fodders, when included in the rotation exert a useful weed-smothering influence.

(2) By planned and careful succession of crops it is easy to keep under control plant diseases and insectpests. It is a well-known fact that some fungi and insectpests attack only particular genera or orders of crops and become very troublesome in case such crops are grown on the same land year after year. Rotation, therefore, offers an easy means to keep such pests under check.

(3) By growing proper crops in suitable order it is possible to maintain the fertility of land on account of the following reasons :—

(*a*) As different crops remove different plant nutrients in different quantities from the soil, proper balance of the nutrients cannot be maintained if the same crop is grown year after year on the same land. Some nutrients, which are removed in large quantities will be exhausted and the land will not be able to produce a decent crop, though there may be plenty of other food nutrients in the soil suitable to grow other crops.

(*b*) *Owing to difference in the root system of various* crops, shallow-rooted crops remove more plant food from the surface, whilst the deep-rooted crops open up the subsoil and take food from the lower layers also.

(*c*) Leguminous crops have got the property of fixing atmospheric nitrogen with the help of bacteria present in the nodules of their roots. Their inclusion in the rotation is, therefore, very helpful in the upkeep of fertility.

(*d*) The fertility of soil is closely linked up with the humus content of the soil. This is of greatest importance in the hot climate and is of special value in the case of extreme types of soils such as sands and clays. By the inclusion of green manuring in the rotations at regular intervals the humus content of the soil can be kept up.

(4) By growing a variety of crops with different sowing and harvesting periods it enables the cultivator to distribute farm labour force (manual and bullock) more evenly. It also ensures return on capital at differrent times of the year.

In view of the above advantages the main points that should be kept in mind when planning a rotation are :—

(*i*) Crops of the same natural order should not follow each other.

(*ii*) Crops of the same type of root system (shallow or deep) should not follow each other.

(*iii*) Leguminous crops should be included in the rotation.

(*iv*) Green manuring and forage crops should be given a place in the rotation at regular intervals.

(*v*) Crops such as potatoes, sugarcane, etc., requiring more thorough cultivation than others, should be included in the rotation as their cultivation means a very good preparation for the following crop.

Except near large towns, where intensive farming (vegetables and fodders) is followed on a limited scale, the general type of farming is very uniform all over the Punjab. The main differences that are found are in the main connected with the supply of water. Other factors such as

(*a*) Physical condition of the soil.

(*b*) Prevalence of weeds.

(*c*) Supply of plant food, and

(*d*) Economic and political conditions

though very important in themselves are of secondary importance. The rotations, therefore, differ largely accordingly to the supply of irrigation water.

Canal tracts. Even on the perennial canals the cropping varies a good deal as shown below :—

Crop.		Lower Bari Doab Canal.		Lower Chenab Canal.		Lower Jhelum Canal.		Pakpattan Canal.	
		Area in '000 acres.	% to total area irrigated.	Area in '000 acres.	% to total area irrigated.	Area in '000 acres.	% to total area irrigated.	Area in '000 acres.	% to total area irrigated.
Wheat	..	389	31·0	892	36·0	308	33·9	212	32·0
Cotton	..	327	26·1	497	20·0	186	20·4	235	35·5
Toria	..	26	2·1	101	4·1	20	2·2	17	2·6
Sugarcane	..	15	1·2	54	2·2	10	1·1	3	0·5
Gram	..	45	3·6	64	2·6	24	2·6	13	2 0
Maize	..	37	3·0	113	4·6	29	3·2	5	0·7
Total	..	1,255	67	2,477	69·5	909	63·4	662	73·3

It will be observed that the area under wheat is proportionately less on the Lower Bari Doab Canal while the area under cotton is high. Whilst the highest percentage of area under wheat is on the Lower Chenab canal, the highest for cotton is on the Pakpattan canal. *Toria*, sugarcane and maize are more important on the Lower Chenab Canal, and gram on Lower Bari Doab Canal. Due to better winter supply of water on the Lower Chenab Canal the area under wheat, *toria* and sugarcane, is the highest. On the Pakpattan Canal the winter supply of water is low. For this reason the percentage of wheat, sugarcane and *toria* grown is comparatively low. In *kharif* season on this canal the water supply is high and the area under cotton is, therefore, the highest of all the canal systems noted above. The area under maize and sugarcane, which require larger quantities of water, is low but this is accounted for by the fact that the area put under cotton is high.

On the Lower Chenab Canal the most important crop is wheat, which occupies about 36 per cent. of the total area put under crops. Maize, sugarcane and *toria* occupy 4·6 per cent. 2·2 per cent. and 4·1 per cent. respectively. Cotton accounts for about 20 per cent. of the area cropped and gram about 2·6 per cent. The balance is made up of *kharif* and *rabi* fodders and miscellaneous crops. On a *square of land the area put under various crops is some*what as follows :—

Wheat 10 to 12 acres.
Gram 2 to 3 acres.
Toria 2½ to 3 acres.
Cotton 4 to 5 acres.
Maize about 1 acre.
Sugarcane ½ to 1 acre.
Chari-guara 2½ acres.
Turnips-*senji* about 2 acres.

24½ to 29½ acres.

This gives an intensity of cropping of about 100 per cent. slightly less in some cases, which is actually the case on the average for the whole of the Lower Chenab. With the above cropping the various rotations followed are :—

1. Wheat, *toria*, cotton. Three crops in three years.
2. Wheat, wheat, *toria*, cotton. Four crops in four years.
3. Wheat, maize, *senji*, cotton. Four crops in three years.
4. Maize, *senji*, cotton. Three crops in two years.
5. Wheat, maize, *senji*, sugarcane. Four crops in three years.

6. *Chari-guara*, gram, cotton. Three crops in two years.
7. Wheat, cotton. Two crops in two years.
8. Gram and wheat. Two crops in two years.

Wheat, which occupies the largest area, finds a place in practically every rotation. *Toria*, which usually follows wheat after a fallow of four or five months, is itself followed invariably by cotton, though this is not considered a good rotation. As the area under cotton is greater than that of *toria*, some of the cotton is also sown after other crops, such as gram or *senji* sown in maize. Some cotton also follows wheat, though, this is known to be a bad practice, because there is very little time left for cultivation; the wheat is harvested in latter half of April and cotton is sown by the end of May and the first half of June. Gram is sown on high and light lands, where, owing to the difficulty of watering, a crop is required which can thrive on almost one watering; it is also sown after *chari* with very little preparation of the soil. Where much gram is sown it is generally an indication of poor water supply or a high proportion of light land.

Senji is often sown in standiug cotton or maize at the end of September or early October. It thus benefits from late waterings of these crops, and is regarded when sown in maize as a good preparation for sugarcane. The preceding maize is heavily manured in such cases, as sugarcane is rarely directly manured. In villages where the water supply is very good, cotton often follows sugarcane, but this is not common, as the preparation of the land after cane is laborious, and the stumps and roots of cane take a good while to decay.

It will be seen that the whole of the farm is never under the same simple rotation. Any such general rotation is practically impossible on account of the small area under summer crops and the necessity for keeping part of the land always in high condition for these crops. This can only be done by concentrating all the available manure on the area where these are grown. But some of the fields are kept more or less permanently under one rotation and others under another, the rotations being dictated by the times of sowing and the condition in which the soil needs to be for the different crops.

The whole system in the main is adapted to suit the water supply from the canal. The local climate and the relative profitableness of the various crops have a secondary influence only. It is, therefore, questionable whether the rotational experiments conducted on some experimental farms with a few crops for a number of years have any practical importance. They may, like the Rothamstead rotations, provide valuable scientific data for future.

In the Lower Jhelum Colony the crops and rotations are more or less similar to those of the Lower Chenab though the intensity of cropping is on the whole less than that on Lower Chenab canal. *

*The utilized supply of the Lower Jhelum Canal and the Lower Chenab Canal for *kharif* and *rabi* are 1 : 1·1 and 1 : 1·3 respectively. In the Lower Bari Doab Canal the proportion is still wider, *i.e.*, the proportion of cotton on this canal is, therefore, high, being often 8 acres per rectangle, though the average comes to 6 acres. Owing to short supplies in *rabi* comparatively little *toria* is grown on this Canal, the actual area being about 2 per cent.

The cropping practice on this canal is usually as follows :—

Wheat	..	7½ acres.
Cotton	..	7½ acres.
Gram	..	2½ acres.
Fodders	..	2½ acres.
Green Manuring	..	2½ acres.
Fallow	..	2½ acres.

The rotations followed are :—

1. Wheat, cotton, fodders.
2. Wheat, cotton, gram.
3. Wheat, cotton, green manuring or fallow.

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*Note by H. W. Nicholson, p. 18 of " Punjab Engineering Conference Report 1918."

These rotations were originally evolved at the B.C.G.A. Farm at Khanewal and have been followed to a more or less extent according to the water supply available by cultivators in L.B.D.C. and Nili Bar Colonies.

In the Nili Bar Colony the proportion between *kharif* and *rabi* is still wider and there is proportionately large area under *kharif* crops, particularly cotton, and comparatively less in *rabi*.

Barani tracts.

As the great bulk of the rain comes between July and September, one would expect *kharif* crops to be mostly grown in *barani* tracts. This, however, is not the case. A *rabi* crop, such as wheat, can be matured on about 2/3rd or half of the water required for say cotton, and hence the *kharif* rains, if conserved in the upper soil by cultivation, are more certain of producing a *rabi* crop sown in the following autumn than of producing a *kharif* crop. Summer crops require water more frequently, and are less able to withstand drought owing to the rate of transpiration being more rapid than is the case with *rabi* crops. Again, it should be noted that the Punjab gets some winter rains, which rarely fail from December to February, which thus help in maturing the *rabi* crops. It is essentially a question of security, therefore, that influences the Punjab farmer to prefer *rabi* crops to *kharif* crops. It should also be noted that the *rabi* crops have got a wider market and are better money crops than the *kharif* with the exception of cotton. As regards the latter, it should be observed that as the rains come very late and stop somewhat early in September, the season is too short for cotton in these tracts. This accounts for the fact that only 15 per cent. of the Punjab cotton crop is grown under *barani* conditions.

Economy of *rabi* season only apparent.

It may be well to correct any possible misinterpretation of the above remarks as indicating that the *rabi* season is a more efficient growing period than the *kharif*. This is far from being the case. *Measurements of the transpiration ratio of *kharif*

*See King's Books and Leather Memoirs.

crops such as maize or millets, and *rabi* crops such as wheat indicate that the former produce a pound of dry matter with much less expenditure of water. Leather in Memoir No. 8, Vol. I. page 179, from work at Pusa, shows that wheat transpired from 550 to 850 lbs. of water for every pound of dry matter produced, whereas maize transpired from 330 to 450 lbs. and *juar* (*chari*) 400 lbs. only. As a practical instance it may be noted that an acre of *chari-guara* mixture grown as fodder and sown at Lyallpur in July and harvested 10 weeks later, though only receiving 4 irrigations, may produce 10 tons, of green fodder, whereas *senji*, which occupies the ground from October to March, *i.e.*, 5 months, and receives five or six waterings only produces on the average 6 tons. There is no doubt that the *kharif* season is an extremely active growing period, and only the supply of water available in canals (not rivers) limits its more extensive use for crop growing.

Rotation in *barani* tracts.

A common practice in *barani* tracts is to grow a *rabi* crop followed immediately by a *kharif*, and then one year's fallow. The reverse *viz.*, growing a *kharif* crop followed by a *rabi*, would be impracticable, as will be clear from a study of the principle enunciated above. This latter practice is, however, rather prevalent in irrigated tracts with only a *kharif* supply, as the succeeding *rabi* can generally be matured on the first watering given at the end of the *kharif* either after or before the harvesting of the *kharif* crop. It is interesting to note that cultivators on *kharif* channels frequently claim that no charge should be made for *rabi* water in such cases, as no actual irrigation is done in that season. The fact, however, that this practice is only possible when *kharif* irrigation is available, and that it is not possible in purely *barani* tracts, is a sufficient answer to the claim.

Common rotation on *barani* land.

Wheat, gram or barley in the *rabi*, followed in the succeeding *kharif* with *chari*, *moth*, *mash*, *til* or cotton according to the type of soil with a year's fallow, is a common practice in *barani* tracts. Again, sometimes, a *kharif* crop is grown and the land left fallow for the succeeding *rabi*, and then cropped again in the *kharif*. This is not so common as growing *rabi* crops only with a *kharif* fallow. The latter practice is sound in that a *kharif* fallow enables the soil to recover much more quickly than in a similar length of fallows in the *rabi*. As labour is one of the main considerations for a farmer, it is necessary that he should arrange his cropping to provide work, as far as possible, for the whole year, and hence a system of *kharif* cropping only or *rabi* cropping only would be uneconomical from that point of view. A feature of all *barani* land is that the farming is always extensive, and cropping rarely attains 100 per cent., and very seldom exceeds this. In canals the farming is a mixture of intensive farming on a small area and extensive cultivation in the main as the supply of water allotted prevents anything else. On wells, on the other hand, an intensive system of frequent cropping is common. As the rapid cultivation of land after rain is desirable, especially in *barani* tracts, there would appear to be a great future for implements like the bar-harrow and cultivators, which cover three or four times as much land as the *desi* plough, and thus conserve the vital soil moisture so essential to success in *barani* cultivation.

Mixture.

In addition to rotating crops, the practice of growing "mixtures" is prevalent throughout the Punjab, especially in *barani* tracts. Common mixtures sown are the following:—

Barley and gram (called *goji*), wheat and gram (called *berra*) wheat and barley, *sarson* and wheat, *toria* and gram, *til* and cotton, *moth* and cotton, melons and cotton, *senji* and cotton, *juar* (*chari*) and *guara*, *chari* and *moth*, maize and *senji* etc. In the main, the reason for such mixtures is that they form a kind of insurance against the vagaries of the season. Thus gram and wheat are typical example of such a mixture. If the season is favourable as regards moisture, the wheat which is more valuable will produce a good crop, whereas, in a dry year the gram, though less valuable, may, at least, be expected to give a fair yield. This mixture has the additional advantage of having a legume in it (gram) and thus enriching the soil in nitrogen. A similar reason accounts for barley and gram, though barley is fairly drought resisting. It is interesting to note that these two mixtures are now rarely seen in canal lands, where such insurance is not necessary, and the extra labour involved in separating the grains after threshing would be a serious factor. Even in canal land partial mixtures are, however, common. Thus a sprinkling of *sarson* is often grown in wheat, the former being removed in January or early February for fodder before the wheat has reached the stage of its maximum demands on the soil. Similarly, melons and *moth* are grown with cotton and removed from May to July before the cotton shades the ground. In the former case the land is also heavily manured. Not more than 10 per cent. of the cotton grown by good cultivators has these two mixtures in, as they interfere with interculture and are not looked upon with favour. Again, the sowing of *senji* in the growing cotton or in maize in early October is a common practice in canal colonies and applies to a third or so of the cotton and maize area. The *senji* is protected in the early stages by the shade of the parent crop, and the water it receives helps in the maturing of the cotton or maize. Another mixture which has become very common of late is *guara* and *chari*. The former alone does not make a good fodder, but mixed with *chari* it not only enriches the land, but as a rule very heavy crops are obtained in this way without unduly impoverishing the soil, as would be the case if *chari* alone were grown. The mixtures *til* and cotton, and *chari* and *moth* are generally seen only in *barani* tracts.

Well lands.

As in canal and *barani* lands, water is the governing factor here also. It is, however, the cost of water that tells in well cultivation. A well 35 feet deep, and giving one-tenth of a cusec of water, will irrigate an acre 2 inches deep in two days of 10 hours each at a cost of Rs. 3. Waterings are more frequent under well cultivation than on canal land, though the quantity given per irrigation is less. Hence, wheat on well land gets 4 or 5 irrigations at a total cost, allowing for repairs and depreciation, of about Rs. 16 as compared to Rs. 4 charged in canal areas. This fact accounts for the high intensity of cultivation in well land as by having crops near the well there is less loss by evaporation and percolation. *Rabi* crops are favoured, as more can be kept going with the limited supply of water than in the *kharif*. Where a town is near vegetables are favoured, and follow one another in rapid succession on the same land. Manure is given in plenty if available, as fallowing, except for very short periods, is impracticable.

Manuring.

Manures are of two types: organic, such as farm yard manure, compost, oil cake and green manuring, and inorganic, like ammonium sulphate, sodium nitrate, etc. Whilst organic manures supply organic matter to the soil to improve its physical condition, as well as plant food, the latter are sources of plant food only.

Farm Yard Manure.

This is the term applied to the ordinary rubbish collected near the steading, consisting of cattle dropping, waste straw, ashes from the fire, etc. Till recently this was the only form of manure known in the Punjab, though in various parts of the country other manures were occasionally used.

The table below gives the analysis of common farm yard manure as done by Mr. Wilsdon at Lyallpur.

Constituents.	Percentage.	lbs. per ton.
Water ..	70 per cent.	
Loss on ignition ..	15 per cent.	
Ash ..	15 per cent.	
Total nitrogen ..	0.4 per cent.	9
Total P_2O_5 ...	0.25 per cent.	6
Total K_2O ..	0.15 per cent.	3½
Available P_2O_5 ..	0.13 per cent.	3
Available K_2O ..	0.13 per cent.	3

As compared with this an English farm yard manure contains about 9 to 15 lbs. nitrogen, 4 to 9 lbs. phosphorus and 9 to 15 lbs. potash per ton.

It will be seen that potash is lower in India. The reason probably is that very little, if any, bedding is used here. Further, dung, which is the basis of farm yard manure, is used largely as fuel here in the form of dung cakes. The method of storing farm yard manure is also defective. The common method is to collect it in the form of a heap on any piece of land easily available. Being thus exposed to the sun, rain and dry winds a good deal of useful material is lost. It should, therefore, be stored in pits preferably under shade and protected from winds. A cheap shallow earthen pit about 3′ deep is good enough. It will then be possible to collect leaves and other rubbish which are otherwise wasted. The manure should be well pressed and covered with a thin layer of soil at the top when the pit is completely filled.

Very little information is available as to the quantity, of farm yard manure produced by a farmer in the year. An attempt, therefore, is made here to estimate it. Assuming ten cattle per rectangle of 25 acres and taking that each animal excretes 30 lbs. per day, the total manure will be 365 × 300 lbs. or 49 tons per year. Assuming that 2/3rd of the dung is used as fuel it leaves only 16 tons for use. An equal amount may, however, be added in the form of sweeping, straw, ashes, etc. The total manure thus available in the year is about 32 tons or 40 cartloads of about 22 maunds each. This quantity is sufficient only to manure 3 out of 25 acres in the year. The cultivator has, therefore, to select the crops which should be manured. His first choice is 1 acre of maize as it does not give good yield without it. Next is vegetables and melon but the area under them is not much. Cotton (2 acres) being a valuable crop in the colonies is the next choice. It thus takes about 8 years to cover the total area of 25 acres in turn.

In *barani* tracts, where rainfall is low, little manure is used, as it does not rot well in the absence of sufficient moisture. It is said to dry the land. Where rainfall is fairly high, as in mountain and sub-montane tracts or where irrigation is practised, as in well-irrigated areas or canal colonies, manuring is essential and every care is taken to collect as much of it as is practicable.

Compost.

Besides water, air, living organisms, and mineral matter a soil contains organic matter which is derived from the remains of plants, animals and soil organisms. When organic matter, such as stubbles and roots of crops, green manure, etc., is added to soil, it is decomposed by the activity of soil organisms into humus. The benefits, which humus confers on the soil are very great indeed and need no elaboration. The making of compost from such wastes like weeds, stalks of cotton, *bhusa* of crops like *toria* not needed for feeding the cattle, sugarcane trash, sugarcane stubbles, uneaten fodder residue, ashes, rubbish, house sweeping, etc., can, therefore, be recommended to the farmers. Recently the attention of Agricultural Department has been concentrated on the utilisation of urban and village waste in connection with "Grow More Food Campaign". The city wastes consist mostly of night soil, fruit and vegetable refuse and liquid dirt. The latter after passing through city drains and sullage works is used to irrigate crops and vegetable areas. The arrangements for dealing with night soil are, however, unhygienic and wasteful. Putting the night soil and ordinary soil in trenches in alternative layers and leaving them alone for sometime has proved to be highly satisfactory. With the help of bacterial activity the mass decomposes and a rich odourless manure is obtained. By this method not only the useful ingredients of night soil are conserved but it is also more satisfactory as regards its comparative cleanliness. A properly-prepared compost from town wastes bulk for bulk is two to three times as rich as the average farm yard manure.

Oil seeds residues, especially *toria* cake, groundnut cake, *mohwa* cake, castor cake and rape cake are also used as fertilisers. These usually contain about 4 to 5 per cent. nitrogen.

In this connection China offers a good example to follow as the Chinese farmer makes the best use of all the possible sources of manure, specially of oil cakes, night soil, and *compost.**

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*Taken from the unpublished report on Chinese Agriculture by Sardar Bahadur S. Kartar Singh submitted to Govt. after his visit to China in May 1944.

Oil Cakes.

The table below gives an estimate of the total production of various cakes and the quantity used as fertilisers in Ch'na :—

Cake.	Production.	Used as [illegible]
	Million cattis.	Million cattis.*
1. *Soyabean cake*	42	11
2. Rapeseed cake	34	33
3. Peanut cake	27	19
4. Cotton seed cake	21	20
5. Tung seed cake	13	13
6. Sesamum cake	8	8
7. Others	15	13
	160	117

*One Catti=1.1 lbs.

It will be observed that nearly 73 per cent. of the total production of all types of cakes is used as fertilisers. In India large quantities of oil seeds are produced and exported. Even cakes in substantial quantities (4,47,000 tons in 1938-39) are annually exported. During the last 50 or 60 years it has been, incessantly, stressed that all the oil seeds should be pressed in the country instead of being exported, so as to conserve and utilise all manurial resources of the country, but so far nothing tangible has been done. What is possible in China could be equally possible in India.

Night soil.

This is the second important source of manure, which is either wasted or not fully ultised in India. In China, both in the rural and urban areas, almost every house and institution has got a latrine, which is often combined with or is located near the pig sty, where pig manure and human excreta are stored together in a small *pacca* tank. From there excreta is removed to a small tank in the field either daily or after some days, depending on the amount collected. It is diluted with water (3 to 4 times its own bulk) and then allowed to ferment for 10 days in a cool place under shade and well protected from wind. It is estimated that 50 per cent. of its nitrogen is lost under ordinary storage conditions but this loss is reduced to 30 per cent. if it is stored without stirring in a cool place under shade and well protected from wind.

On the average its production per annum may be taken

Production.

to be about 10 picules (1 picule-112 lbs.) per head or 50 picules (70 *maunds*) per family of 5 members (husband, wife and three children 12 years of age or over). As one family cultivates about 20 mows (3 acres) of land, the human excreta produced by the family is enough to manure 1/3 to 1/2 of the holding, the remaining area being manured with pig manure, ashes, compost, etc. The value of human excreta before the war varied from 10 to 30 cents per picule depending on the locality. In May, 1944 the price had gone up 1,000 times, the price of solid excreta being 250 cents and of liquid 50 cents per picule. In towns there are big contractors who buy the night soil from big institutions and store in *pacca* cemented tanks, separating the solid from liquid faeces.

In case of rice it is applied just before transplanting

Application.

by sprinkling the liquid in standing water. In case of sorghum (*jowar*) it is applied after transplanting to each plant separately. It is also applied to the crops like wheat, barley, rapeseed, corn, Irish potatoes and sweet potatoes.

Another interesting feature that came to our notice when touring in the country was that young boys were seen with a ladle in their hand and a basket under their arm picking up small pieces of manure found scattered on the roads or any other places. This keeps the roads clean, as well as adds, to the manurial resources of the country.

From the above-given account of manurial resources of China it will be observed that every possible source of manure is utilised and that the use of oil cake and human excreta is the outstanding feature of Chinese agriculture.

This consists in growing a green crop, preferably and

Green Manuring.

generally a legume, and ploughing it in the field, when in flowers. This has been practised in India from ancient times. The crops most commonly used are san-hemp and *guara*. The former is preferred in submontane tracts as *guara* does not grow well there. In other parts, specially canal colonies early *guara* is preferred.

Though this practice has been recommended by the Agricultural Department for the last 30 years but it has not been taken up by the farmers to any appreciable extent. In spite of the fact that no water-rate is charged by the Irrigation Department for crop so grown, the total area green manured till 1945 did not exceed 30,000 acres per year. The probable reason is that water supply on these canals is only sufficient under optimum condition for 100 per cent. intensity of cultivation and the cultivator does not feel inclined to sacrifice a crop by ploughing it in. It must be remembered that a crop of *guara* is worth at least Rs. 40 an acre as fodder and ploughing it in means an expenditure of Rs. 40 per acre and not Rs. 3 the cost of seed and one ploughing, as is commonly believed.*

During 1945 under "Grow More Food Campaign", seed for such crops has been supplied free of cost and it is expected that one *lac* acres will be grown for this purpose. It should be noted that in order to take advantage of this concession the cultivator will have to buy an iron plough worth Rs. 20 for the purpose. It remains to be seen how far the Department succeeds in pushing on the practice of green manuring.

The method of green manuring is as follows :—

A heavy *sohaga* is run over the crop in the direction along which ploughing is to be done. When the crop is thus laid flat a furrow turning plough is used to bury the crop. If the latter is not available *desi* plough may be used, but in this case there should be a few men to assist in putting the stalks in the furrows by hand, so that the soil moved by the plough in making the next furrow may cover them properly. The field may then be left after going over it with the *sohaga* until the green manure has decayed to some extent. It is advisable to water the field a few days before ploughing in the crop. Four to five weeks after the burying of the crop the cultivation required for the succeeding *rabi* may be begun.

The green manure has been found to be very useful in sandy soils as it has a binding effect on such soils.

Artificial or inorganic manures.

Artificial fertilisers provide plant food in the available form. Broadly speaking they are of three types: nitrogenous fertilisers, phosphatic fertilisers and potash fertilisers. There are four principal nitrogenous fertilisers, *viz.*, nitrate of soda, sulphate of ammonia, nitrate of lime, and calcium cynamide. Of these the first two are by far most common in this country and nitrate of soda is probably the most valuable of the sources of active nitrogen in common use. It is obtained from the Chillian saltpeter mines by a process of crystallisation. The commercial product usually contains 95 per cent. pure sodium nitrate with 15½ per cent. nitrogen. It also contains a trace of iodine, which is considered to be of great importance in the nutrition of animals, as the iodine content of a crop is dependent upon the iodine content of the soil. Since nitrate of soda is highly soluble in water and is directly available to the growing plant, it is usually applied in the form of top dressing to the crop. Sulphate of ammonia is more popular than nitrate of soda nowadays. It is manufactured largely as a product of coal gas and coke industry. It contains about 20 per cent. nitrogen. Since sulphate of ammonia is not available immediately to the plant it is more suitable for use at the sowing time, though top dressing like sodium nitrate can also be done.

Commercial nitrate of lime contains about 13 per cent. nitrogen. Broadly speaking it has the same advantages as nitrate of soda. It is, however, more hygroscopic than nitrate of soda and is, therefore, not very popular.

Calcium cynamide is manufactured from atmospheric nitrogen by combining nitrogen with calcium carbide by means of electric process. This product mainly contains about 19 per cent. nitrogen. Like sulphate of ammonia it undergoes nitrification before plants are able to use it. It should, therefore, be applied at the sowing time, or at least a weak or two before planting.

Besides these there are other nitrogenous manures such as dried blood (10 per cent. nitrogen), horn and hoof meal (12 to 14 per cent. nitrogen), tannery waste (5 to 10 per cent. nitrogen), hair waste (8 to 10 per cent. nitrogen), shoddy (14 to 15 per cent. nitrogen), etc.

Phosphatic fertilisers.

These fertilisers contain phosphoric acid combined with lime in greater or less proportion. Most important of these are mineral or rock phosphates, super-phosphates, basic, slag and bone fertilisers. The mineral phosphates are found in natural deposits in some parts of the world but most of it is used for conversion into popular superphosphate with sulphuric acid. By this process the tricalcic phosphate is turned into mono-calcic phosphate. Another product in the reaction is sulphate of lime or gypsum. The superphosphate usually contains 30 to 35 per cent. phosphate of lime (13½ to 16 per cent. phosphoric acid).

Basic slag is the product of bessemer process of steel manufacture resulting from the removal of phosphorus from iron by means of lime. It contains about 40 per cent. phosphate of lime or 18 per cent. phosphoric acid. Basic slags of lower grade are also available.

Bone fertilisers besides containing phosphoric acid also contain small amounts of nitrogen. These fetilisers are produced from bones left over after the manufacture of greese, gelatine and glue. In some cases the raw bones may also be crushed, but usually fat which is very valuable commercially is removed before the bones are crushed into meal. The degreased bone meal usually contains 45 per cent. phosphate of lime (20 per cent. phosphoric acid) and 3¾ per cent. nitrogen. The bone meal flour contains about 60 per cent. phosphate of lime (27 per cent. phosphoric acid and generally about 1 per cent. of nitrogen). Some grades of dissolved bones are also used as fertilisers.

Potash fertilisers.

Number of different salts are obtained mainly from mines in Germany and Alsace-Lorraine. Potash salts are also obtained from Spain. The most important of these are muriate (chloride) of potash (50 to

53 per cent. potash), the sulphate of potash (48 to 51 per cent. potash). Some lower grade salts, such as kainite (12½ per cent. potash), etc., are also available. Of all these manures, however, the muriate of potash, which contains some amount of common salt as well, is by far the most important. Wood ashes are also fairly good sources of potash.

The nitrogenous fertilisers stimulate above ground parts of the plant. Excessive nitrogen, however, exaggerates these effects and retards ripening. The plants are more susceptible to attacks of fungus diseases if excessive quantity of nitrogen is applied. In the case of grain crops it may cause lodging. Inadequacy of nitrogen on the other hand may result in stunted growth of the plants and result in poor yield.

Phosphoric acid encourages the development of grain and promotes early ripening. It also stimulates root development. It is, therefore, valuable on *barani* lands. It is specially valuable for legumes particularly berseem (see last para. of this chapter.)

The potassic fertilisers are closely associated with the production of carbo-hydrates (sugar and starch) in plants. This is of great importance for crops like potatoes, sugar beet, etc.

Manurial requirements of the Punjab soils.

As regards the manurial requirements, the Province may be divided into two regions. The first region comprises the central and western plains area. Here the climate is hot and generally dry. Under these conditions the soil organic matter is rapidly oxidized and therefore, there, is no accumulation of organic matter. This type of soil, therefore, responds to application of both nitrogen (ammonium sulphate) and organic manures, like farmyard manure and green manures.

The second region comprises the montane and sub-montane areas. The climate varies from humid to subhumid and, therefore, the soil is comparatively better supplied with nitrogen and organic matter. However, both laboraand field experiments have shown that these soils are deficient in phosphorus and therefore respond to phosphatic manures. Potassic manures have shown no response anywhere. Investigations for finding out the manurial requirements of different crops under different climatic conditions on an economic basis are in progress and at this stage it is not possible to give any precise information on this aspect of the problem.

Rare elements.

In recent years it has been found in some of the Western countries that minor and trace elements such as Boron, Magnesium, Manganese, Zinc, etc., exert great influence on the yield and quality of crops. In India very little attention has been paid to this important problem. It is, however, of utmost importance in order to make full use of the manures. No doubt, it is admitted that the study of influence of such elements on the crops is not simple and easy because of the lack of knowledge with regard to their requirements and the danger of toxicity of excessive quantities of elements, etc., yet no progress can be made in the absence of any experimental work.

Place of legumes in the Punjab agriculture.

A passing reference to the advantages of including leguminous crops in the rotations in order to maintain or even improve the fertility of land has already been made. Great importance of this subject, however, deserves special attention.

Most of the common crops which are grown in this province, such as wheat, maize, *chari*, sugarcane, toria, cotton, etc., are very exhaustive. The inclusion of legumes such as *senji*, *metha*, *berseem*, lucern, gram, *moth*, *mung*, *mash*, etc., which have the characteristic of fixing atmospheric nitrogen with the help of bacteria in the nodules on their roots, is very helpful. Moreover, on account of being rich in protein their mixture with cereal yields a nutritious and palatable fodder. The capacity for fixing nitrogen is, however, different in different leguminous crops. For instance, crops like *berseem* which give more than one cutting fix larger amount of nitrogen than others like *senji* and *metha* which give only one cutting. This seems to be due to the fact that by repeated cutting, the roots get stimulated and their active period for fixing nitrogen is prolonged.

Let us examine the position of Punjab in this respect. The area under leguminous crops together with the total area cropped under different conditions of farming, *viz.*, canal irrigation, *barani* and well irrigation combined is given below:—

Type of Area.	Area under leguminous crops.	Total area cropped.	Percentage of legumes to total.
	Acres.	Acres	
Canal irrigated ..	1,348,889	12,219,754	11
Barani and well-irrigated ..	6,917,585	20,441,246	34
Total ..	8,266,474	32,661,000	25

It will be observed that the position is not bad for the cropped area as a whole, while it is good for the barani and well-irrigated areas taken together where legumes form about 34 per cent. of the total area cropped. In the canal-irrigated area, however, the position is very bad, the average figure being 11 per cent. only. So far as individual canals are concerned the percentage of legumes to total area cropped varies considerably. For instance, it is 25 per cent. on Ghaggar canals, 18 per cent. on Western Jumna, 17 per cent. on Sirhind on the one hand and only 2 per cent. on Eastern canals, 9 per cent. on Upper Chenab canal, and 10 per cent. on Lower Chenab Canal on the other. Other canals occupy intermediate position.

It may also be noted that it is in canal-irrigated areas that legumes are needed most as the yields are high and crops are more or less sure, whereas in *barani* areas reverse is the case, *i.e.*, yields are low and due to erratic monsoon, crops are not reaped every year.

A comparison with Egypt where canal irrigation is extensively practised and where high yields of cotton have been obtained for a very long period may be made here:

	Area in Hectares (2.47 acres).
Wheat	594,962
Maize	628,896
Great Millet	163,654
Barley	110,808
Rice	200,149
Cotton	749,386
Sugarcane	28,656
Other non-leguminous crops ..	41,425
Total of non-leguminous crops ..	2,517,936
Berseem	739,995
Leguminous Food crops	239,488
Other leguminous crops	15,620
Total of leguminous crops ..	995,103
Total area cropped ..	3,513,039

These figures show that the percentage of leguminous crops to total area cropped is about 28. Incidentally it may be mentioned that by putting proportionately more area under *berseem* it has been possible for Egypt to attain average intensity of cropping as high as 160 per cent. Here is a lesson to be learned from the Egyptian agriculture, *i.e.*, we should encourage the growing of leguminous crops particularly those like berseem which give several cuttings in the canal irrigated tracts. The difficulty of procuring good reliable seed at reasonable cost is there but the Agricultural Department is doing all it can to solve it.

*Further it has been observed that the application of superphosphate to the *berseem* crop at sowing time

*"Phosphate Manuring of Legumes," by Parr and Bose. "Indian Farming," Vol. V, No. 4, 1944, and Vol. VI, No. 5, 1945.

increases the yield by 100 to over 150 per cent. and the phosphate content of the *berseem* plant by 250 to over 400 per cent. In the case of cowpeas following the manured crop of *berseem* the yield of fodder was not increased very much, but there was a 200 per cent. increase in the phosphate content of the plant. There is also a considerable variation in the capacity of various legumes to respond to the application of phosphates. The application of phosphates also stimulates nitrogen fixation. The amount of nitrogen fixed by legumes from the atmosphere is in proportion to the yield and vigour of the legume crop. The application of phosphatic manures to those legumes, which respond better, offers an effective means of adding nitrogen to the soil, and at the same time increased production of the fodder and increased soil fertility for the succeeding cereal crop.

References

(1) Bailliere's Encyclopaedia of Scientific Agriculture, Vol. I.
(2) Administration Reports of the P.W.D. Irrigation Branch.
(4) Note by H.W. Nicholson: Punjab Engineering Conference, 1918.
(5) Memoir No. 8, Vol. I by Leather.
(6) Unpublished Report on Chinese Agriculture by S.B.S. Kartar Singh submitted to Govt. after his visit to China in 1944.
(7) Cost of green manuring by W. Roberts.
(8) Season and Crop Reports of the Punjab.
(9) Phosphate Manuring of Legumes by Parr and Bose—Indian Forming Vol. V, No. 4, 1944 and Vol. VI, No. 5, 1945.
(10) Place of Legumes in Punjab Agriculture by S.B.S. Kartar Singh—Seasonal Notes, April 1940.
(11) Green Manuring and hot Weather Cultivation in the Punjab by W. Roberts—Agricultural Journal of India, 1913.
(12) Manures in the Punjab by W. Roberts.
(13) Estate Farming in India by W. Roberts—Indian Farming, April 1942.

CHAPTER VIII

IRRIGATION.

A study of maps A and B in Chapter I shows clearly the uneven distribution of rainfall in the Punjab from June to September and from October to May respectively. Only parts of the Districts of Ambala, Hoshiarpur, Gurdaspur, Sialkot and Rawalpindi and the whole of Kangra and Simla get over 25 inches in the summer months. West of a line passing from Rawalpindi through Gujrat, Amritsar, Karnal and Gurgaon get less than 20 inches When we get as far West as Zone 3, the rainfall is between 10 inches and 5 inches and Zone 2 and 1 get under 5 inches. The picture for the winter months in Map B is still more sombre. There are only two Districts in the whole Province which get over 10 inches in Winter. Not only is the rainfall inadequate but it is often irregular and uncertain and sometimes can do more harm than good.

Importance of irrigation.

These maps however show clearly the wonderful position of the province as regards rivers. With the Indus on its Northern boundary and Jumna on its South Eastern boundary and five rivers, *viz.*, the Jhelum, Chenab, Ravi, Beas and Sutlej inside, the land of the five rivers is indeed blessed.

From what has been said above the supreme importance of irrigation in the Punjab can be realised.

Sources of irrigation.

The large canals constructed by damming of the great rivers of the province are the main sources. Out of a total cropped area of 33 million acres, 17 million acres or 52 per cent. is irrigated and 77 per cent. of this is by canals. In other words 13 million acres or about 40 per cent. of the total cropped area of the province is irrigated from canals. Only 41,000 acres are irrigated from tanks. The balance representing about 25 per cent. of the irrigated crops is irrigated from wells.

Wells.

Irrigation from wells has proceeded from times immemorial. It is estimated that there are 329,320 masonry and 17,592 non-masonry wells, in the province.* Masonry wells are important mostly in Jullundur, Multan, Muzaffargarh, Sialkot and Ludhiana, whilst the non-masonry wells are mostly popular in the districts of Multan, Hoshiarpur, Dera Ghazi Khan, Muzaffargarh and Gurdaspur. It will be observed that wells are mostly found in *khadir* areas, *i.e.* areas adjacent to rivers and sub-montane districts where canal irrigation is not possible, spring level is high and sub-soil water is fit for irrigation†. In some places such as parts of Multan, Amritsar, Ludhiana, etc., where canal water is available in summer season only, wells are used in winter season to supplement the canal supply.

During the last three-and-a-half decades there has been an increase in the number of wells as well as in the well irrigated area. In 1909-10, there were 273,988 wells and area irrigated by them was 2,985,574 acres whereas in 1943-44 the corresponding figures were 346,912 and 4,216,056 respectively.

A well with water level at 25 feet from the surface and sunk further 10 feet in the water cost before the war about Rs. 800. The capital value of all the wells at the above cost of Rs. 800 for each well is, therefore, about 25 crores of rupees, as against about 34½ *crores* as the direct and indirect capital outlay up to 1937-38 for major or productive works of Punjab canals. There appears to be no reason why state effort need be restricted only to the construction of canals and tanks and why Government should not construct wells on the same analogy. The capital involved is heavy—25 crores against 34 crores on canals and the area irrigated is over 4 million acres. If this is done the resources of the cultivator will be fully employed on actual cultivation, manuring and growing of crops. The Government will be

*Season and Crops Report, 1943-44.

†Water containing more than 1 part of mineral salts in 1.000 is considered to be unfit for Irrigation purposes. The presence of sodium salts, especially sodium carb onate is considered to be highly injurious.

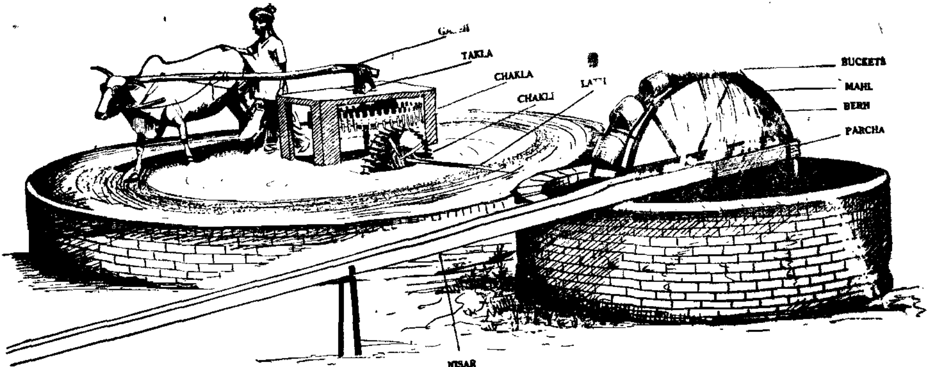
justified in charging a small tax along with land revenue for the amenity. In order to encourage well sinking the Government should also help by giving correct and free advice about locating sites with a dependable supply of water and insurance against failure in addition to giving financial help*. At present all that the government is doing in connection with well irrigation is to arrange for the boring of wells for augmenting the water supply on payment or *takavi* loans for sinking of wells. As a rule well irrigation is not practised where the depth of water is much over 35 feet as the cost of lifting water beyond that depth is excessive in comparison with the value of crops thus raised. In tracts like Gurgaon, however, the wells are generally 50 to 60 feet deep and are extensively used for *rabi* waterings because that tract has a fairly secure rainfall and wells merely supplement the rain and crops generally get two irrigations as compared to 4 or 5 in districts like Jullundur and Sialkot. Under such circumstance, it pays to lift water even from greater depth than is usually considered profitable, as otherwise the crop will altogether fail.

Water Lifts.

Water from canals usually flows into the fields by force of gravity, but in case of wells and tanks water has to be lifted up to the surface before it can be applied to crops. Sometimes, when land is situated at a higher level, water from canal has also to be lifted to the level of fields. Various contrivances used for lifting water are discussed below:—

(*i*) *Persian Wheel.*—Irrigation from wells is in the main carried out by means of the Persian wheel (*rahat*). It consists of a large drum (*bair*), over which passes an endless rope or iron ladder (*mahl*) with buckets attached to it at distances of one or two feet. The ladder with buckets reaches below the surface of the water in the well. The drum with the buckets is revolved by means of a simple round-about gear worked by a pair of bullocks. The lever to which the bullocks are yoked gives motion to a horizontal

*"Food Production and Well Irrigation," by S. Joshi.



PERSIAN WHEEL (JHALAR)

Fig. 24.

toothed disc (*chakla*), which through the medium of a cog-wheel (*chakli* & *lath*) turns the drum. The buckets are either earthenware vessels holding from 1½ to 2 seers of water or are made of iron holding 3 to 6 seers of water. Some simple mechanical deductions as regards the output and work are given below:—

(*a*) Increase in the size and number of buckets increases draft and discharge.

(*b*) Increasing the size of the *bair* increases the velocity of chain draft and output; whereas decrease in size has the reverse effect.

(*c*) Altering the relative gears of the *chakla* and *chakli* affects output and draft. Increase in number of teeth in the *chakla* increases draft and output and *vice versa*.

(*d*) The larger the circle through which the bullocks move the less the draft and the output.

It will be seen from above that the persian wheel is very flexible and, therefore, adapted for varying water level depths. In the common form of persian wheel the bullock track is on one side of the well, as in the case of *jhalar* used for lifting water from streams and tanks but sometimes it is round the well also.

The persian wheel varies in detail from place to place. With regard to the material used for construction they may be divided into two types, *viz.*, (*i*) wooden: and (2) Iron. In a typical wooden persian wheel the *mahl* is generally made from hemp, buckets are earthen and other parts are made of wood. Sometimes the *mahl* is made of date-palm fibre. A typical iron persian wheel is wholly made of iron. Iron persian wheels are a comparatively new introduction, and are gradually replacing wooden machines. But in certain tracts due to lack of initiative, capital and facilities, people are still sticking to the old type of machine. A study of the mechanical efficiency of the two types of machines has shown that iron persian wheels are on an average 28 per cent. more efficient than wooden persian wheels. The lower efficiency of the latter is to a great extent due to low discharge caused by excessive breakage of earthen buckets. Perhaps for this very reason in several places persian wheels are partly made of iron and partly of wood, *chakla* and *chakli* being of wood and *bair, mahl* and buckets of iron. In such places the cultivators also believe that the draft of such machines is less than that of those wholly made of iron. An improved persian wheel has also been evolved by the Department of Agriculture. Through the use of roller and ball bearings, reversible *chakla* and *chakli* and proper attachment of buckets to chain, its efficiency has been considerably improved. Its price is, however, much higher than that of an ordinary iron Persian Wheel, *viz.*, Rs. 250 as against Rs. 125 and 100 (pre-war prices) for iron and wooden types respectively, and for this reason it has not found favour with cultivators.

Persian wheels are usually worked by draft animals, but there are a few machines in the Province worked by electricity and oil engines also. On an average the draft of an iron persian wheel is about 1¼ cwts. and with bullocks a discharge of about 1/7th cusec from a depth of about 25 feet is obtained. One man or a boy is required to drive the bullocks and another to control water. But the former can be dispensed with if bullocks are blind folded and the man controlling water is near the well to give an occasional shout to the animals.

(*ii*) *Charsa or Ramiokos.*— This is perhaps the second commonest water lift in the Province. Some 20 years back it was very common but now it has been largely replaced by persian wheels. Its use is mostly confined to the tracts where the water table is rather low and rainfall on the whole good, so that only a few irrigations are needed to mature crops, *e.g.*, certain parts of Gurgaon and Delhi. In some districts like Ludhiana, this water lift has been almost entirely replaced by persian wheel.

Charsa consists of a whole bullock hide, with the corners cut off and tied by leather throngs to an iron ring 18 to 24 inches in diameter. It holds from 24-42 gallons of water. The bag is pulled up by a pair of oxen by means of a rope passing over a pulley at the top of the well and attached to the bucket and to the yoke of the oxen. The cattle walk down an inclined plane. On the bag reaching the level of the discharging trough, it is emptied by an attendant stationed there for the purpose. The emptying of the bag is facilitated by the driver jerking the rope on receiving a signal from the man at the well. The toggle or *kili* attaching the rope to the yoke, is detached and the bag thrown into the well, where it descends by its own weight but controlled by the attendant on the well. The bullocks turn round and walk up the incline for the next load. The inclined-plane tends to even the work for the cattle as they take advantage of their weight when going down land and they climb up without load on their return journey. Though one pair of bullocks and two men can work a *charsa* but two pairs and three men work it more conveniently as it helps in regularizing the work since when one pair is going down, the other is coming up. The average discharge of a *charsa* worked by two pairs of bullocks may be taken to be about 1/6th cusec.

(*iii*) *Dhenkli or counterpoise lift.*—*Dhenkli* is a poor man's water lift. It consists of a bucket made of iron or leather, suspended by a rope to the end of a pole, which is carried and evenly balanced by a counter-weight on a stout upright support, on which it works in a see-saw fashion. The lift is worked by manual labour and the counterpoise is of such weight that no great exertion is required to depress the lift when empty or raise it when full.

This device is used for lifting water from tanks or wells 5 or 6 feet deep. It is usually worked by one man, but there are some forms which require more than one man. This lift is used in the Punjab on holdings which are too small for economical use of bullocks and the sub-soil water is not very deep.

(*iv*) *Swing basket* (*jhatta*).—This consists of a basket or a shovel like scoop and is swung by two men, one standing on either side holding the ropes. It is suitable only for low lifts. Each swing catches some water and lifts it, say, 1 to 3 feet high to an upper channel. Sometimes the basket is suspended from a tripod but this is not essential.

(v) *Pumps.*—Centrifugal pumps are usually worked by electric motors or oil engines. Small pumps drawing as much water as the ordinary persian wheel or a little more may be installed on the ordinary wells, but for large pumps wells must be capable of giving at least ½ cusec or about 11,000 gallons per hour. Most wells in the Punjab would suffer from "blowing" if water were pumped to this extent from them. To remove this defect, the wells may be bored or "Tube Well" may be installed.

Boring.

It simply means the boring of a hole in the well and putting in of a plain or better still a Tube Well pipe in the bore in order to utilise the water in the lower water-bearing strata which rises to the previous water-table or higher by its own pressure. In the Punjab, this method has been followed for nearly 30 years and in many parts of the Eastern Districts it has proved to be very successful. At some places Artesian wells have been discovered and probably many more could be discovered if experiments were systematically conducted. Some such wells near Rawalpindi give water-supply above soil surface level from bores over 200 feet deep.

Departmental work, extent of it and procedure.

The Well Boring Section of the Punjab Agricultural Department, undertakes the boring of wells used for agricultural purposes with the object of increasing their yield. Trial Bores are also sunk at the site of proposed wells to ascertain the suitability or otherwise of the sub-soil conditions. The standard size of casing tube used in such borings is 7 inches, and the usual maximum depth to which such bores are sunk does not exceed 300 feet. Provided the well owner supplies a regular and necessary daily labour and the surface strata are not unusually hard, the well borers can bore down to this depth with the ordinary standard hand boring plant used by them. An estimate to cover the cost of pipes, strainers and other materials to be used in the well, together with overhead charges (during War overhead charges are not levied), the borer's footage allowance and inspection charges, if any, will be supplied in writing by the Well-Supervisor direct or through the well-borer to the well owner. In the three years ending **1943-44**, 540 wells were bored annually in the Punjab, and 81 per cent. of these bores turned out to be successful. Those, who are interested in having their wells bored for increasing the water supply, should give a written application for boring to the local Tehsildar or to the Well-supervisor of their *ilaqa*. For details please consult the Department of Agriculture Punjab, leaflet No. 84.

Tube-wells.

The tube-well consists essentially of a strainer which is inserted in the soil so as to reach several feet below soil water level. The upper part of the tube consists of a plain iron pipe. With a tube-well, supplies up to 3 cusecs or even more can be obtained by having a sufficiently large pipe put into the requisite depth of water-bearing strata. A fairly large number of tub-wells have been put up during the last few years, especially in the United Provinces. In the Punjab, tube-wells have been used in suitable sites mostly on the farms of the Agricultural Department or by the Public Health and Railway Departments. Some wells have also been sunk by large land-owners for irrigation purposes. More recently two irrigation schemes have been brought into effect by the Punjab Government. One of them is known as the Qadian Scheme and the other as Karol (Lahore) Project. The former started with 3 tube-wells, but one of the tube-wells has been abandoned, so the scheme is now confined to two tube-wells only. The Karol Project has been prepared to irrigate a tract of land of 30 square miles lying between the left bank of the Ravi River, and the right irrigation boundary of the Shalamar distributory, and contemplates to sink and operate 30 tube-wells which have been sunk in this area and are working satisfactorily.

It has been observed in the Punjab that in the majority of tube-wells the yield begins to fall after sometime. The reasons for this fall have been investigated and found to be partly mechanical and partly chemical. In the case of former choking of strainer is caused by the deposition of small particles of soil or deflocculated clay and in the case of latter it is due to the chemical action of the salts in the sub-soil water on the strainer.

Complete failure of the tube well may also occur in another way. The water-bearing strata of sand contain a certain percentage of fine soil particles. If the velocity of pumping is high enough to remove these fine particles, prolonged pumping will result in the cavitation of the sourrounding sub-soil which ultimately may cause collapse. To exceed limiting velocity is, therefore, highly dangerous. As a matter of fact, the velocity should be kept at the lowest economic limit, for this is helpful in avoiding the chemical choking as well. When the sub-soil water contains calcium bicarbonate, with the reduction of pressure of such water the carbonic acid gas is liberated and the calcium carbonate *is precipitated on the strainer.*

In order to avoid choking the slot area should be as large as possible and the strainer should not be made up of such metals as mild steel, cast iron, zinc, aluminium and copper which are liable to be attacked by sodium salts. Brass is not readily attacked by salts normally present in soils while cadmium is non-corrodible under ordinary conditions. If strainer is sufficiently corroded complete *collapse will follow and the well will fail.*

In order to avoid corroding and choking, many types of strainers have been evolved and put on the market by various people. Of these Brownlie Slip Strainer, Improved Pottery Strainer and Ess-Bee Strainer are worth mentioning. The first two were designed by Mr. T. A. Miller Brownlie, Agricultural Engineer to Government, Punjab, for many years. The Pottery Strainer which is an advance on the Slip Strainer *consists of pottery sections.* Recently the pottery has been replaced by a composition similar to that of the quadrants of Slip Strainer which were made up of asbestos bound with pitch and other agents. The Ess-Bee Strainer consists of coir cord wound on a steel frame of horizontal strips. It is claimed to be free from clogging and corrosion. Experiments carried out in the Irrigation Laboratory tend to bear out this claim. But this strainer is very delicate and requires careful handling. Moreover, coir taints the water and, therefore, it renders the water unsuitable for drinking purposes. Slip Strainer can be obtained from Ishwar Pottery Works, Delhi, Improved Pottery Strainer from M. Mohd. Subhan, Proprietor Kashmir Pottery Works, Sialkot and the Ess-Bee Strainer from Messrs. Sarup and Bansi Lal, Lahore.

It has been found that the great majority of areas in the Punjab are unsuitable for a large scale project on account of the uncertain geology of the sub-soil. There are numerous instances of brackish sub-soil water entirely unfit for irrigation although there are many wells where the water is good. It is, therefore essential to carry out proper examination of every single site before the well is sunk. In the U. P., the conditions are very favourable for Tube-Well Irrigation. There, the sub-soil is light in texture, uniform in quality and free from salts and the sub-soil water stream flows parallel to the crusted warpings. Consequently there is uniformity in respect of water-table below soil surface. Such conditions lend themselves to standardisation of plants and methods. Besides, in the U. P., the entire water-table is inter-connected and the whole system contributes to the discharge of the tube-well system, but in the Punjab the sub-soil water-stream does not run parallel to the crusted warpings and there are sheets or beds of clay which cut off the main sub-soil stream resulting in pockets of water in some cases. If a pump is, by chance sunk in one of these, the discharge is likely to cease abruptly after a short time. However, in areas adjacent to rivers where the spring-level is high, sub-soil water is sweet and plenty of it is available, tube-wells are likely to prove of highest benefit.

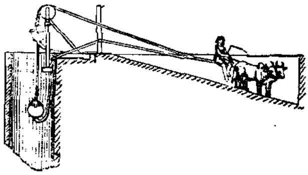
Department's advisory works.

Those, who are interested in tube-wells, should apply to the Agricultural Engineer to Government Punjab, Lyallpur, who after inspecting the site, will supply the estimates for sinking the tube-well. For any other detail Agricultural Engineer to Government, Punjab, Lyallpur, may be consulted.

Lifts used in other provinces

The lifts described so far are met with in the Punjab. There are however, some more lifts which are used in other Provinces and it is possible they may have some scope here also. These are, therefore, briefly described below:—

(*i*) *The Self-Delivery or Sundio Kos.*—This is a self-discharging *charsa*. It consists of an ordinary *charsa* with a leather tube varying in length from 6 to 10 feet at the bottom. A strong rope is attached to the main bucket. The other end of this rope is passed over a pulley fixed almost directly above the lip of the receiving trough and about 4 feet above the top of the well. A second thinner rope is fastened to the smaller mouth of the leather bucket or the tube in a manner which will not obstruct the flow of water through the small mouth. The other end of the thin rope is passed over a roller which works on the lip of the



Sundio Kos.
Fig. 25.

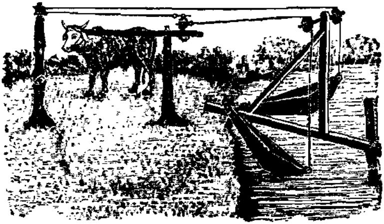
receiving trough. These two ropes are attached to the yoke of a pair of bullocks, and their lengths are adjusted so that the narrow half of the bucket or tube doubles up alongside the broad half of *charsa* and the two mouths of the leather-bucket are level with each other as the bucket ascends or descends in the well. When the bucket reaches the top of the well, the narrow mouth follows its own rope over the roller and delivers the water into a receiving trough whilst the broad mouth is by means of its rope carried to the pulley four feet higher up. This ensures that the bag is completely emptied of water. Bullocks walk down an incline as in the *Ramiokos*, but instead of being detached they back to point of starting instead of turning round. For this work good moving active bullocks are used; heavy animals are unsuitable. The outlet from the receiving trough is sufficiently large to allow the trough to empty itself as fast as it is filled, and small enough to keep up a continuous flow in the channel which it feeds.

This lift is unknown in the Punjab, but is extensively used in Western India. It has the advantage of saving labour of one man, and is very suitable where depth does not exceed 30 to 35 feet.

(*ii*) *The Double Mote.*—Bullocks walk in a circle. Two bags are attached by a winding rope to a drum, one unwinds while the other winds up.

The drum is on a vertical axis, and ropes pass over pulleys on the rim of the well. The cattle walk on a level and get no benefit from their weight as they do in the case of ordinary *charsa* when walking down an inclined plane. This lift is not in general use anywhere in India.

(*iii*) *Baldeo Balti.*—This is an ingenious device for lifting water up to 5 feet. It consists of two large boat-shaped buckets of iron, hinged on to a piece of wood on the edge of a water-tank or channel. These buckets are raised alternately by means of strings or ropes attached to the



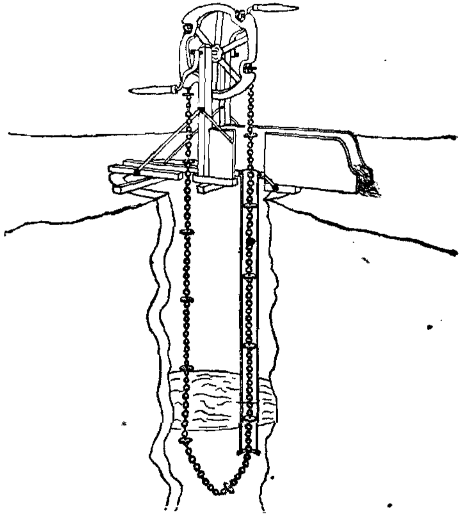
Baldeo Balti
Fig. 26.

yoke-pole turned round by a bullock or a pair of bullocks, so that when one of the buckets goes down and gets filled with water, the other comes up and discharges the water. The arrangement of the ropes is rather complicated. In one case it is attached directly to the yoke-pole after passing over a pulley and in case of the second bucket it passes over two pulleys, one of which is fixed on the top of another post.

(*iv*) *Egyptian Jhallar.*—This is a low-lift *jhallar* obtained from Egypt and tried at Tarnab Agricultural Farm, Peshawar. The practicable maximum lift in this case is 5 feet. The lift at Tarnab is only 2′—8″. It is worked by a single bullock and delivers 1.5 cusecs which can irrigate 1 acre in 1 hour 20 minutes. Its draft is 120 lbs. and its efficiency about 76 per cent. The main point in its mechanism is that the water lifted is delivered almost at the ground-level unlike that of Persian wheel or local *jhallar* where water is delivered about 4 feet above ground level. This is a sheer waste of energy which is proportionately very high in case of low lifts. The cost of this *jhallar* is about Rs. 380 and it is anticipated that there is a good scope for this sort of lift in some parts of the Province.

(*v*) *Egyptian Screw.*—This is largely used by the "Fellah" or Egyptian cultivator. It consists of a cylinder of wood about 12″ to 24″ in diameter and 3 to 9 feet long, inside which is a series of planks arranged in the form of a screw. At each end of the cylinder is an axle and this rests on two supports, one in the water and the other by the delivery trough. The cylinder is turned round like a turbine, and the water rushes through. A slope of 35° to 45° is generally employed for the cylinder to facilitate the raising of water. This is useful for more shallow depths, up to 4 feet. It can be made for about Rs. 30. A 6-feet machine, 15 inches in diameter, can be easily worked by one man and can discharge about 200 to 300 gallons of water per minute from a depth of about 1½ feet.

(*vi*) *Chain Pump.*—This is worked somewhat on the same principle as the Persian wheel. A pulley is keyed on to a shaft which gets motion, either by handle, when manual labour is employed, or by a round-about gear, when bullock power is used. This pulley carries on it an endless chain, which having discs on it at intervals of a foot, is made to ascend through a tube which descends from the top of the well to 2 feet below the surface of water. The discs are about the same diameter as the tube. In the improved pattern, leather-washers strengthened by iron discs are used. The volume of water lifted is proportionate to the size of the tube. The discs on the chain fit into corresponding notches on the pulley; therefore it does not slip back. Two or more tubes could be put on the same shaft. A chain pump with 4-inches pipe will lift 2,500 gallons per hour from a depth of 20 feet. At depths over 20 feet this pump does not work well because of the increase of friction and loss of water by drainage along edges of discs.



Chain Pump
Figure 27.

A somewhat similar contrivance is in use in China for lifting water from small depths. This is an inclined wooden trough with a wooden endless chain fitted with wooden discs. As bamboo is easily available there, it is all made of bamboo wood. The endless chain is moved by means of paddles worked by man power and wooden discs moving up the inclined plane carry water to the top. It may be worked by one or two persons according to the height to which it is to be lifted. In the case of higher lifts, these machines are fitted at various levels and are worked in conjunction with each other. A cheaper contrivance, all made of bamboos, is also used for lifting water from deep running streams. No external power is used for working it. The running stream moves the drum carrying small bamboo buckets.

Cost of lifting water.

The cost of lifting or pumping water by various devices varies a good deal from year to year and place to place, because conditions as regards prices, water supply, depth of water-table, etc., do not remain the same in different years and different areas. To give only one figure for the whole of the province, is therefore, not likely to represent true conditions. However, in order to give only a rough idea of the costs and show the method of arriving at these figures some information is given in the following pages. Since, along with the money costs the quantitative data (as far as possible) are also given here, an estimate of costs for a particular time and locality can also be made by the application of local agricultural and economic conditions to these figures.

The cost of lift irrigation may be divided into three main heads: (1) overhead charges; (2) power costs; and (3) manual labour charges. The overhead charges consist of capital cost of sinking the well, installation of the lift, construction of necessary buildings as in the case of tube-well, and expenditure incurred in connection with repairs and skilled attendance to the well and lift. The capital cost of the well and the lift includes the interest and depreciation on their initial cost, interest at the rate of 4 per cent and depreciation according to expected life. In order to determine these charges per acre. the total expenses under this head have been divided by the total area irrigated, which depends upon several factors, such as the annual rainfall, the depth of water-table, supply of water in the well, and nature of crops grown. The power costs consist of the cost of bullocks in the case of bullock-worked lifts, that of electricity in the electrically-driven lifts, and of fuel, oils, etc., in the case of water lifts worked by oil engines. The manual labour charges are those for the labour required for driving bullocks and controlling or directing water in the fields. This labour has been charged at the rate of five annas per man per day of 8 hours. In the case of Persian wheel a boy will do for driving the bullocks, his charges have, therefore, been calculated at the rate of 3 annas per day.

Cost of lifting water by bullock-driven Persian wheel from open well.—Information on the cost of irrigation by Persian wheel has been published regularly every year in "Farm Accounts" since 1928-29. For detailed information readers are referred to these publications of the Board of Economic Inquiry. But as a typical case the following figures are given:—

	Rs.	Rs.
(1) *Overhead charges*—		
(*a*) Well—Capital cost Rs. 800		
Interest at 4 per cent.	32.00	
Depreciation at 3 per cent.	24.00	56.00
(*b*) Persian wheel—capital cost Rs. 120		
Interest at 4 per cent.	4.80	
Depreciation at 25% on Rs. 40 (chain) ..	10.00	
Depreciation at 10 per cent. on Rs. 80 remainder	8.00	22.80
(*c*) Repairs and replacements		4.00
(*d*) Oil for lubrication		2.00
Total ..		84.80
Area cropped—25 acres.		
Number of acre irrigations—125.		
Overhead charges per acre irrigation ..		0.68
(2) *Bullock labour*—		
Average time taken to irrigate an acre with an average discharge of 1/7 cusec—2.31 days.		
Cost of Bullock labour per working day—Rs. 1.		
Therefore cost of bullock labour per acre irrigation		2.31
(3) *Manual labour*—		
A man at 5 *annas* and a boy at 3 *annas* per day for 2.31 days		1.16
Total ..		4.15

Excluding manual labour the total cost per acre irrigation comes to Rs. 2.99. Since the average depth of watering under well irrigation is about 2.64 inches, the cost per acre *inch irrigation calculates to* Rs. 1.13 *and* Rs. 1.57 *excluding* and including manual labour respectively.

On this basis the average cost per acre of bringing to maturity some important crops is as follows:—

Crop.	*Average No. of *irrigations* 1928-29 to 1937-38.	COST OF MATURING AN ACRE.	
		Including manual labour.	Excluding manual labour.
		Rs.	Rs.
Cotton ..	4.9	20.34	14.65
Maize (for Grain) ..	3.9	16.19	11.66
Sugarcane ..	9.8	40.67	29.30
Wheat ..	3.5	14.53	10.47
Kharif fodders ..	3.6	14.94	10.76
Rabi fodders ..	6.4	26.56	19.14

Cost of lifting water by electrically-driven Persian wheel from open well. Data about the working of two electrically-driven Persian Wheels installed at the Ludhiana and Jullundur Agricultural Farms are available. The Ludhiana Persian wheel was set up at a cost of Rs. 500 in 1936. Its average discharge during 1937-38 was 55 gallons per minute, depth of water level from ground surface being 39 feet. Detailed cost of lifting water by this lift in 1937-38 is shown below:—

	Rs.	Rs.
(1) *Overhead charges*—		
(*a*) *Well* (same as in bullock-driven persian wheel)		
(*b*) *Persian wheel*: Capital cost Rs. 500		56.00
Interest at 4 per cent.	20.00	
Depreciation at 25 per cent. on Rs. 60 (chain)	15.00	
Depreciation at 10 per cent. on Rs. 440 (remainder)	44.00	79.00
(*c*) Repairs, lubrication, etc.		
Repairs	43.02	
Lubrication (grease)	8.31	51.33
Total overhead charges ..		186.33
Number of acre irrigations—172.19		
Overhead charges per acre irrigation		1.08

*Calculated from "Farm Accounts", 1928-29 to 1937-38.

		Rs.	Rs.
(2) *Motive Power:*			
Total units consumed—2,487.			
Total cost of electricity at of Re. -/1/6 per unit		233.15	
Meter rent at As. 12 per mensem ..	..	9.00	
		242.15	
Cost per acre irrigation ..	..		1.41
(3) *Manual labour*—			
Total hours worked—2,711.82			
Therefore, time required to irrigate one acre—15.75 hours or 1.97 days	..		
Cost at As. 5 per day ..	..		0.61
Total cost per acre irrigation ..	..		3.10

The average depth of irrigation for this persian wheel was 2.29 inches. Therefore, cost per acre inch irrigation works out to Rs. 1.09 and Rs. 1.35 excluding and including manual labour respectively.

The Jullundur persian wheel was installed in 1934. For the period 1934-35 to 1937-38 its average discharge was 49 gallons per minute and its total average cost was Rs. 3.24 excluding manual labour and Rs. 4.67 including manual labour. The average depth of irrigation was 3.01 inches. Thus, corresponding figures per acre inch irrigation were Rs. 1.08 and Rs. 1.55 respectively.

Cost of lifting water by electrically-worked pump from open well.—As already noted, only small pumps can be put up on ordinary wells. One such pump was installed at the Jullundur Agricultural Farm in 1929 at a cost of Rs. 900. Its average discharge during the year 1937-38 was 81.6 gallons per minute and cost of irrigation was as follows—

		Rs.	Rs.	Rs.
(1) *Overhead charges*—				
(*a*) *Well* (same as in ordinary bullock Driven Persian wheel)			56.00	
(*b*) *Machinery* (motor, pump, pipes, etc.) *Present value—Rs. 322.15.*				
Interest at 4 per cent. ..	..	12.89		
Depreciation at 7 per cent.	..	22.55	35.44	
(*c*) *Repairs lubrication, etc.*				
Repairs ..	..		74.25	
Lubrication ..	..		3.81	
Total	..		169.50	
Number of acre irrigation ..	..		177.49	
Overhead charges per acre irrigation	..			0.95

		Rs.	Rs.
(2) *Cost of current*			
Current consumed—7,833 units			
Cost at Rs. -/1/6 per unit	..	734.34	
Cost per acre irrigation	..		4.14
(3) *Manual labour*			
Total hours worked—2,526.31			
Time required to irrigate an acre—14.23 hours or 1.78 days			
Cost of manual labour at As. 5 per day			0.55
Total cost per irrigation	..		5.64

The average depth of irrigation in this case was 3.1 inches. Thus, cost per acre inch irrigation was Rs. 1.64 and Rs. 1.82 excluding and including manual labour respectively.

Cost of pumping water by electrically worked tube-well.—Information collected from a private tube-well at Nankana Sahib for the year 1938-39 is given below:—

Worked by 7½ B. H. P. electric motor		
Strainer tube 60′ × 7″		
Water-table below ground level	..	19 feet
Discharge	..	400 gallons per minute
Total working time	..	3,647 hours
Total energy consumed	..	20,060 units
Area cropped	..	163.40 acres
No. of acre irrigations	..	939.6 acres
Average number of irrigations	..	5.8

COST OF IRRIGATION :

	Rs.	Rs.
(1) *Overhead charges*		
(a) *Tube-well, pump and masonry work*		
Capital cost—Rs. 4,667.25		
Interest at 4 per cent.	186.69	
Depreciation at 7 per cent. on Rs. 4,037.25 (tube-well and pump)	282.61	
Depreciation at 1½ per cent. on Rs. 630 (masonry work)	9.45	
	478.75	
(b) Repairs	*Nil*	
(c) Lubrication	2.00	
(d) Pay of the driver (Driver attends to 2 pumps and was paid Rs. 20 per mensem)	120.00	
Total	600.75	
Overhead charges per acre irrigation		0.64

	Rs.	Rs.
(2) *Cost of current*		
Energy charges at the average rate of 11.4 pies per unit for 20,060 units	1,194.38	
Meter rent	12.00	
Total ..	1,206.38	
Cost of current per acre irrigation		1.23
(3) *Manual labour*		
Time taken to irrigate an acre once 3.9 hours or 0.49 days; cost of 2 men at As. 5 each		0.30
Total ..		2.22

The average discharge of the pump was 1.07 cusecs and the average depth of irrigation was 4.17 inches. On this basis the cost of irrigation per acre inch comes to Rs. 0.46 when manual labour is excluded and Rs. 0.53 when it is included.

Cost of pumping water by tube-well worked by oil engine.—An account of an oil-engine driven tube-well at the Attari Agricultural Farm (District Amritsar) for the year 1940-41 is given below:—

Worked by an 8/10-B.H.P. Oil-engine, "Pettin."

Date of installation	.. February 1938.
Depth to water	.. 18 feet.
Total hours worked	.. 1,515.
Average discharge	.. 0.982 "cusecs."
Number of acre-irrigations	.. *393.50.*

	Rs.	Rs.
I. Overhead Charges.		
1. Tube-well, pump and masonry work (Rs. 4,786.25).		
Interest @ 4 %	191.45	
Depreciation at—		
5 % on Rs. 2,947.73 (tube-well)	147.39	
7 % on Rs. 1,132.52 (pump)	79.28	
1½ % on Rs. 706 (masonry)	10.59	
Total ..	428.71	
2. Repairs	70.53	
3. Pay of driver	298.31	
Total ..	797.55	
Cost per acre-irrigation, $\frac{797.55}{393.50}$		2.03
II. Consumption of Oils, etc.		
Diesel, 720.50 gallons @ Rs. 0.61 (approx.) ..	439.42	
Mobile, 47.88 gallons @ Rs. 2.00 (approx.) ..	95.75	
Kerosene, 10.39 gallons @ Rs. 1.12 (approx.) ..	11.64	
Total ..	546.81	
Cost per acre-irrigation, $\frac{546.81}{393.50}$		1.39

III. Manual Labour.

Time required per acre-irrigation, $\frac{1,515}{393.50}$ = 3.85 hours = 0.48 days.

		Rs
Wages of one man @ Rs. 0.27 per day, 0.48 × 0.27 ..	..	0.13

∴ Total cost per acre-irrigation :

		Rs.
I. Overhead charges	..	2.03
II. Consumption of oils	..	1.39
III. Manual Labour	..	0.13
Total	..	3.55

Depth of irrigation	..	..	..	3.75 inches

Thus, the cost per acre inch irrigation is Rs. 0.95 when excluding manual labour and Rs. 0.91 when including it.

Cost of lifting water by Charsa.—The following figures of cost collected from a holding in the Nawanshehr Tehsil of Jullundur District will give an idea of the cost of irrigation by this lift:—

			Rs.	Rs.
A. *Charsa* worked by two pairs of bullocks : Depth of water-table 27 ft.				
(*a*) *Overhead charges*				
(*i*) Well Capital cost—Rs. 700				
Interest at 4 per cent. ..	..	..	28.00	
Depreciation at 3 per cent.	..	..	21.00	49.00
(*ii*) *Charsa* and other equipment				
Interest at 4 per cent. on Rs. 51	..	..	2.04	
Depreciation at:—				
3 per cent. on Rs. 33 (trough)	..	..	0.99	
200 per cent. on Rs. 10 (*charsa*)	..	..	20.00	
20 per cent. on Rs. 2 (pulley)	..	..	0.40	
20 per cent. on Re. 1 (axil) ..	..	..	0.20	
20 per cent. on Re. 1/8 (stand)	..	..	0.30	
100 per cent. on Rs. 2/4 (Rope)	..	..	2.25	
20 per cent. on Re. 1/4 (Others)	..	..	0.25	26.43
(*iii*) Repairs, etc.	..	..		4.00
			Total ..	79.43
Total number of acre irrigations	..	..	90	
Cost per acre per irrigation	..	..		0.88
(*b*) *Bullock labour*				
Number of pairs used per day	..	..	2	
Cost of upkeep of a pair of bullocks per day		..	0.68	
Cost of supply of 2 pairs ..	..	..	1.36	
Days required to irrigate an acre	..	..	2	
Cost per acre per irrigation	..	..		2.72
(*c*) *Manual labour*				
Wages of 4 men for two days	..	..		2.48
			Total ..	6.08

Taking depth of irrigation as 2.64 inches the cost per acre inch calculates to Rs. 2.30 including and Rs. 1.36 excluding manual labour

Cost of lifting water by dhingli.—In this connection the following figures were collected from Ludhiana:—

	Rs.	Rs.
(*a*) *Overhead charges*		
(*i*) Well, capital cost—Rs. 125		
Interest at 4 per cent. per annum	5.00	
Depreciation at 3 per cent. per annum ..	3.75	8.75
(*ii*) *Dhingli*, capital cost—Rs. 6/7		
Interest at 4 per cent.	0.26	
Depreciation at:—		
3 per cent. on Rs. 3 (trough)	0.09	
10 per cent. on Rs. 1/4 (*Dhingli*)	0.12	
100 per cent. on As. 5 (Supports)	0.31	
33 per cent. on As. 8 (Rope)	0.17	
5 per cent. on Rs. 1/6 (Buckets and chain) ..	0.07	1.02
(*iii*) Repairs and Replacements		1.50
Total ..		11.27
Number of acre irrigation—51.		
Therefore, cost per acre per irrigation		0.22
(*b*) *Manual labour*		
Wages of one man per day	1.00	
Wages of one boy per day	0.20	
Total ..	1.20	
Days required to irrigate an acre—4.		
Cost per acre irrigation		4.80
Total ..		5.02

From the figures given above, it will be observed that the tube-wells and electrically-driven Persian wheels are the cheapest lifts. Next comes the ordinary Persian wheel. All other lifts are dearer than the Persian wheel worked by bullocks. But in the case of electrically-worked lifts it must be borne in mind that these figures do not include the cost of transmission line which is very heavy. Since it varies with the distance of the well from the supply poles, it is very difficult to give an average figure for his purpose. However, the rates at which the Punjab P.W.D. (Hydro-Electric, Branch) charges for the transmission line are given below:*—

Length and capacity of service		*Above*	*Monthly rental for service line per ft. run upto*	*Pies*
For service line upto 1,500′ and of capacity	(*i*)	0.K.W.	5 K.W.	$1\frac{1}{4}$
	(*ii*)	5 K.W.	15 K.W.	$1\frac{1}{2}$
	(*iii*)	15 K.W.	20 K.W.	2
	(*iv*)	20 K.W.	30 K.W.	$2\frac{1}{2}$
For service line above 1,500 ft. in length and/or of capacity above 30 K.W.			(*i*) Cost including departmental charges of Service line or (*ii*) A monthly rental of $1\frac{1}{2}$ pies per month per rupee of estimated cost *excluding departmental* charges of service line.	

From these charges it is obvious that the cost of transmission line even for a moderate length, will wipe out the advantage in favour of the electricity worked lifts. It is, therefore, of utmost importance that these charges as well the rates for the current used on agricultural holdings should be reduced as far as possible. Failing that, the use of electricity for agricultural purposes is not likely to find much favour with farmers.

Canal irrigation.

The Government Canals, irrigate 13 million acres annually—(see page 139.)

The most important canal irrigated Districts are—

(1)	Lyallpur	with 95%	croppea area canal irrigated.
(2)	Multan	with 88%	do.
(3)	Montgomery	with 86%	o.
(4)	Lahore	with 70%	do.
(5)	Muzaffargarh	with 67%	do.
(6)	Sheikhupura	with 58%	do.
(7)	Shahpur	with 57%	do.
(8)	Jhang	with 56%	do.

Besides the state-owned canals there are some private-owned canals, notably in Shahpur, Ferozepur, Karnal and Kangra Districts. The total area irrigated from Private-owned canals in 1943-44 was 494,865 acres.

*Taken from Form for the industrial Supply of Current.

The chief canal systems in the Province are as follows:—

(1) *The Western Jumna Canal.*—It was opened in 1820. It irrigated 1,144,355 acres (British territory 1,056,950 acres and Patiala State 87,405 acres)*, an average for three years, ending 1940-41. The culturable commanded area was 2,278,008 acres in 1941-42. It takes off from Jumna at Tajewala and irrigates a tract comprising parts of Ambala, Karnal, Rohtak and Delhi in the British territory.

(2) *Sirhind Canal.*—It was opened in 1883. It irrigated 2,101,018 acres (1,384,661 acres in British territory and 716,357 acres in Patiala, Nabha and Jind States) in the three years, ending 1940-41. The culturable commanded area in the British territory was 2,090,278 acres and in the Indian States 1,629,000 acres in 1941-42. It takes from Sutlej at Rupar, and irrigates parts of districts of Ludhiana, Ferozepore, besides Indian States of Patiala, Nabha and Jind.

(3) *Sutlej Valley Canals.*—These canals were designed to cover a gross area of 1,006,000 acres perenniel and 2,582,000 acres non-perenniel in Lahore, Ferozepore, Montgomery and Multan districts of the Punjab and certain areas of Bahawalpur and Bikaner States. The construction was started in 1921-22 and completed in 1933.

In order to make certain improvements in these canals a feeder canal, known as Montgomery-Pakpattan link was subsequently added.

(4) *Upper Bari Doab Canal.*—It was opened in 1860-61 as compared to 1820 for the Western Jumna Canal. It irrigated 1,293,320 acres, an average of three years, ending 1941-42. The culturable commanded area is 1,445,797 acres, and it irrigates parts of Gurdaspur, Amritsar and Lahore. This is the second oldest perennial canal in the Province.

(5) *Lower Bari Doab Canal.*—It was opened in 1913-14 and commanded 18 lakh acres of gross area and 1,438,166

*Figures for the canals are taken from the Administration Report of the Punjab Irrigation Department, 1941-42.

acres of culturable area in 1941-42. It takes from river Ravi at Balloki.

(6) *Upper Chenab Canal.*—It was opened in 1913. It takes from the Chenab at Marala and commanded 1,533,852 acres of gross area and 1,444,992 acres cf culturable area in 1941-42. It irrigates portions of Sialkot, Gujranwala and Lahore and delivers its main supply of 11,770 cusecs to the Ravi at Balloki, the water being used for the Lower Bari Doab Canal.

(7) *Lower Chenab Canal.*—It was finished in 1891 and irrigates the *Doab* between the Ravi and Chenab comprising a gross area of 3,671,267 acres, of which culturable commanded area is 2,872,985 acres. It takes from Chenab river at Khanki. It irrigates parts of Gujranwala, Sheikhupura, Jhang and Lyallpur district.

(8) *Haveli Canals.*—These canals came into operation in 1939. The main canal is cement lined. It was constructed with the object of transferring the water of rivers Jhelum and Cheuab into Ravi near Sidnai, by constructing a barrage at Trimmu. These canals were designed to safeguard the then existing irrigation from inundation canals on the Chenab, particularly the Sidnai canal. This project was framed to cover a gross area of 700,000 acres of perennial and 8½ lakh acres of non-perennial.

(9) *Upper Jhelum Canal.*—It was opened in 1916. It commanded an area of 502,292 acres only in 1941-42. It takes from Jhelum at Mangla. After irrigating a part of Gujrat district it delivers its remaining supply of 10 thousand cusecs to the Chenab river above Khanki.

(10) *Lower Jhelum Canal.*—It was opened in 1901. It commanded culturable area of 1,239,597 acres in 1941-42. It irrigates the *Doab* comprising Shahpur district and parts of Gujrat and Jhang. It takes from Jhelum at Rasul.

It is interesting to note that the Upper Jhelum, Upper Chenab and Lower Bari Doab canals were constructed as a Triple Project. These three canals are linked with the Lower Jhelum and Lower Chenab and all five are worked as a unit and supplies apportioned by the Irrigation Secretariat at Lahore. In practice the Upper Jhelum Canal delivers water now to the Lower Chenab in winter, whereas the Upper Chenab carries water to the Lower Bari Doab, as the Ravi is a very uncertain winter river, with little water to spare after meeting the demands of the Upper Bari Doab Canal. Further details regarding any particular canal can be had from the Annual Administration Reports of the Irrigation Department. In general the perennial canals take off from the rivers which will give ample command over the area to be irrigated. The main canal and the larger branches follow the ridges or high ground as far as possible. During the summer season the canals generally run full, but in winter, owing to shortage of supply, various branches and distributaries run in rotation.

Planning rotations.

The adjustment of supplies in the five linked canals, *viz.*, the Upper and Lower Jhelum, Upper and Lower Chenab and the Lower Bari Doab, is made by the Chief Engineers in consultation with the Superintending Engineers. The latter arrange the supplies of the branches and distributaries of their respective canals in consultation with the Executive Engineers.

Block system of land.

In the Canal Colonies generally the land is divided into squares as in Lower Jhelum and Lower Chenab canals, or rectangles, as in Lower Bari Doab canal containing 25 units, which is a *Killa* (1.1 acres approximately) in case of a square and an acre in the case of a rectangle. A square thus measures 27.8 acres on the Lower Jhelum and Lower Chenab canals and a rectangle 25 acres on the Lower Bari Doab canal. A number of squares or rectangles varying from 30 to 70 or say 750 to 1,750 acres form what is known as a *chak*. Usually a separate outlet is given for an area of 20-30 squares. Thus a *chak* has often 2 or more outlets with supplies varying from 1½ to 3 cusecs. A discharge of one cusec (one cubic foot per second) controlled on an average 367 acres in 1941-42, 123 acres in *kharif* and 244 acres in *rabi*. This corresponds to about 13 squares or 15 rectangles of land. There are, however, considerable variations in the area controlled by a cusec from canal to canal as shown below:

*Canal.	Area irrigated per cusec at distributary head. Acres.		
	Kharif	Rabi	Total
Western Jumna	153	308	461
Sirhind (British)	175	277	452
Upper Bari Doab	143	314	457
Lower Bari Doab	116	168	284
Upper Chenab	107	299	406
Lower Chenab	135	219	354
Upper Jhelum	124	294	418
Lower Jhelum	162	246	408
Pakpattan	108	169	277
Dipalpur	92	1,199	1,291
Eastern	63	1,164	1,227
Mailsi	85	1,271	1,356
Haveli	89	177	266
Rangpur	51	405	456
Average (weighted) ..	123	244	367

In the case of the first three canals and of the Upper Chenab and Upper Jhelum the duty is high because of good rainfall supplementing irrigation. It is hard to give a good reason for Lower Jhelum being distinctly better than the Lower Chenab, especially as the proportion of *rabi* and *kharif* crops is 1.6 to 1 in Lower Chenab and only 1.5 to 1 in Lower Jhelum. The comparatively poor sowing of the Lower Bari Doab Canal is not explained by proportion of *rabi* to *kharif* which is the same as on the Lower Jhelum canal. The Lower Bari Doab Canal area, however, gets very little rainfall except in the upper reaches—being less than 12″ per annum west of Montgomery and as low as 5″ in Khanewal. In case of the Haveli canals the irrigation is not yet fully developed, as the duty is low, but the present proportion of *rabi* and *kharif* indicates better winter supply, than on the Lower Chenab canal, Lower Bari Doab canal or Lower Jhelum. As regards Dipalpur, Eastern and Mailsi canals the winter well irrigation supplementing *rauni* accounts for the very high *rabi* and apparent high duty.

*Administration Report of the P.W.D. Irrigation Branch, 1941-42, page 17.

These canals mainly run in the *kharif* only. They have no masonry head works as a rule and no weir. Hence they depend for supplies on floods in the river. These canals are mainly on the Sutlej and along the lower reaches of the Chenab and the Indus and irrigate a total area of about 1½ million acres chiefly in D. G. Khan, Muzaffargarh and Shahpur districts.

Inundation canals.

In addition to canal and well irrigation a small area is flooded by the rivers annually while in flood. This land is sown after the rivers recede, and receives as a rule, very little preliminary cultivation.

Sailab land.

The management of water after it leaves the distributary into the zamindara watercourse is in the hands of the village authorities or farmers. Each square or rectangle gets so many *pahars* (3 hours supply of water) as will enable the turn or *wari* to be finished in 10 to 14 days. If the supply is say 2 cusecs for 20 squares or rectangles, then each unit can get 4 *pahars* in every turn or *wari* after 10 days or six *pahars* if the *wari* is to be had after 15 days.

Water management.

To facilitate distribution and economise water, each *killa* or acre is divided into a number of compartments (*kiaris*). According to Canal Regulations this number is supposed to be 8. As one cusec will irrigate an acre in one *pahar* each *kiari* takes between 20 and 25 minutes. With a supply of two cusecs the time is halved, and it is in that case difficult to control the water if 8 *kiaris* are maintained. The zamindar usually arranges matters, so that he has 20 minutes to half an hour for each *kiari*. This figure of 8 *kiaris* per *killa* is, therefore, suitable for supplies below 1½ cusecs; above that a smaller number should suffice. It must be remembered that the cutting of the bank of the watercourse in 8 different places to irrigate an acre entails much labour, and tends to weaken the banks and cause leakings, especially when the supply is considerable. The plan of a square and its watercourses is shown in Fig. 28 (as on page 168.)

If water comes from direction A B, the first *killa*, to be irrigated would be No. 21 and after that 22, 23, 24, 25 and then 20, 19, etc., the last to be watered being No. 5, if the whole square is to be irrigated. It will be seen from

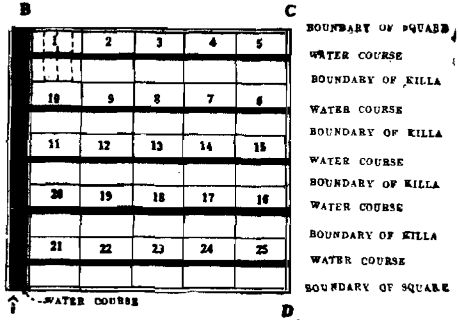


Figure 28. Plan of a square in the Canal Colonies.

the above diagram that the watercourse traverses the middle of each *killa*. If 8 *kiaris* are made in each *killa*, there will be 4 on each side of the watercourse. *Killa* No. 1 has been divided accordingly. Frequently, while conforming to regulation as regards number of *kiaris* the zamindars irrigate one from the other, and may for instance only make two openings from each bank instead of four. This is much more wasteful of water than if only 4 *kiaris* or plots of 2 *kanals* each had been made from the very beginning and irrigated separately. The *kiari bunds* are made as a rule after sowing by means of the *jandra* (see figure 23) for which two men are employed.

Ordinarily very few cultivators follow this method of layout. Usually there is only one watercourse for two lines of *killas*. Thus if a farmer owns two squares of land situated side by side, he makes only 5 watercourses. But when a farmer owns only one square he has to make 3 water-courses in this piece of land. The arrangement of the water-courses is modified according to the contour of land.

Water is charged for on an acreage basis. A schedule of rates is fixed for each class of crops. Ten to twelve classes or schedules of rates are generally in force on each canal for flow and lift irrigation separately. These rates vary slightly from canal to canal. The rates for some important crops on the Lower Chenab Canal are as follows:—

Cost of irrigation by canal.

Crop.	*Rate.* Rs.	a.
Wheat	4	4
Oilseeds	4	4
Cotton	5	4
Maize	4	0
Sugarcane	11	0
Gram	3	4
Fodders	2	8

For details and rates prevalent on different canals, the Administration Reports of the Irrigation Department may be consulted.

With a flow of $1\frac{1}{2}$ cusecs of water the time required to irrigate one acre comes to about 3 hours for *rauni*, and 2 hours for each of the subsequent waterings. Usually two men are required to attend to the application of water. Including the cost of manual labour at Rs. 0.31 per man per day the cost of irrigation of the above crops works out as follows:—

Crop	Cost of irrigation per acre excluding manual labour	Cost of manual labour.	Cost including manual labour.
	Rs.	Rs.	Rs.
Wheat ..	4.25	0.62	4.87
Toria ..	4.25	0.64	4.89
Cotton ..	5.25	1.06	6.31
Maize ..	4.00	1.02	5.02
Sugarcane ..	11.00	2.12	13.12
Gram ..	3.25	0.47	3.72
Kharif fodders ..	2.50	0.84	3.34
Rabi fodders ..	2.50	1.45	3.95

A comparison with figures given for lifts will reveal that canal irrigation is much cheaper than any other source of irrigation. The actual charge is so small compared to the value of the crop that this factor has practically no influence on the cropping followed. Not only that, it is also admitted that canal irrigation has increased the yield of crops on already cultivated areas and has made it possible to bring under cultivation new lands which were so far lying waste for want of irrigation water. But one of the greatest shortcomings of the canal irrigation is that water cannot be had whenever needed. Often, during the critical periods, as is the case in autumn, when for cotton and wheat demand for water is high, the supply available is low and canal closures are frequent. For this reason whenever a farmer gets his water turn, he tries to use as much of it as possible. This results in considerable waste of valuable water. Besides this, it tends to lower the nutritive value of produce and brings about deterioration of soil through accumulation of salts or water-logging.

Volumetric supply.

The question of proper use of water has exercised the minds of those interested in irrigation improvement for many years. The Irrigation Commission of 1901-03 drew particular attention to the supply of water on volumetric basis and laid stress on the importance of evolving a reliable "module" for this purpose. Since then, a number of modules and semi-modules have been evolved and of these the Kennedy's Gauge-Outlet, Gibb's Module and the Harvey and Stoddart's Standing-Wave-Outlet have received most attention. The Gibb's Module was designed to give a constant discharge with varying head within a certain minimum and maximum and was partly independent of the downstream level. In the latter respect the three types were fairly satisfactory and no increased supply could be obtained by silt clearing in the watercourse as is the case with an ordinary outlet. But in order to increase the discharge the farmers adopted other ways, such as plugging of the module at the top. The Kennedy and Harvey types aimed at giving a proportional discharge and were thus semi-modules. The actual discharge passing through either of these modules could be ascertained by reading a calibre gauge at the mouth. The Harvey type can be made into a constant supply outlet. Mr. Crump at Balloki made important improvements in it.

Advantages of payment by volume to the zamindar.

If water was paid for by volume, the zamindar has every inducement to make the water go as far as possible and to use it in any way he finds most profitable. It is true that the charge of water is so low in comparison to the value of crop that in general an effort is made to sow as large an area as possible. Supposing, however, that with a certain definite supply a zemindar ordinarily sows 11 acres of wheat per square from which he gets an average yield of 15 maunds. Now if he sows 12 acres, the average yield may go down to 14 maunds, *i.e.*, his total yield is 168 maunds as compared to 165 on 11 acres. In other words he gets only 3 maunds on the extra acre and yet on acreage basis he pays water-rate and land revenue on that acre at the same rate as for others. Hence beyond a certain point there is no strong inducement to economy by keeping to the present system, whereas if paying on a volumetric or contract basis the charge would be the same whether 11 acres of wheat are grown or 12.

Again, payment by volume would give the farmer a freer hand in utilising the water on his best land and thus getting a high return per unit of water. Another advantage of the volumetric sale of water would be that of getting rid of the *patwari* and his exactions.

In order to encourage taking of water by volume, the rates charged per cusec per day should be such that the total charge is not more than ordinarily paid at present. To begin with *i.e.*, in 1918-19, these rates were Rs. 6 and Rs. 3 for *rabi* and *kharif* respectively, but later on in 1920-21 they were reduced to Rs. 5 and Rs. 2-8 respectively. But even at this rate many did not take volumetric supply, for there were many difficulties involved. In the first place, when supplies are liberal, a distributary often carries more than the designed discharge and the ordinary outlet benefits accordingly, whereas if water is taken by a module, this benefit cannot be availed of for the supply remains constant.

Again remission (*kharaba*) is given on a fairly liberal scale if the crop is poor or a failure but is not given in case of volumetric supply. These disadvantages, combined with the fact that the rate is comparatively high, especially for *rabi*, militates against the extension of this reform. Thus only a few large estates got water on this basis. One such farm is at Iqbalnagar (Montgomery District) which took 9 cusecs of water in *kharif* (1st May to 30th September) and not more than 7 in *rabi* (1st October to 30th April) on volumetric basis from 1918 to 1936. Barring a few years in the beginning, the rates of payment were Rs. 2.8 (Rs. 2-12-9) and Rs. 4.28 (Rs. 4-4-6) per cusec per day of 24 hours for *kharif* and *rabi* seasons respectively. Since 1936 this farm has been taking water on contract system at the rate of Rs. 450 per cusec per season. The amounts paid according to these two systems in comparison with that of the ordinary system are shown below:

	Zamindara system	Volumetric system	Contract system
	Rs. a. p.	Rs. a. p.	Rs. a. p.
Kharif 1935 ..	3,438 2 0	3,349 14 0	
Rabi 1935-36 ..	3,397 1 0	3,413 6 6	
Total 1935-36 ..	6,835 3 0	6,763 4 6	
Kharif 1938 ..	4,702 3 0		4,050 0 0
Rabi 1938-39 ..	3,774 14 0		3,150 0 0
Total 1938-39 ..	8,477 1 0		7,200 0 0

It will be seen from these figures that to take water either on contract or on volumetric basis is cheaper than the ordinary method of water-rate assessment. Water on contract has also been taken by a few Government Agricultural farms; their rates for the years, 1943-44 and 1944-45 were:

Farm	Total charge			Dis-charge.	Rate per cusec.		
	Kharif	*Rabi*	Total	Cusecs	*Kharif*	*Rabi*	Total
	Rs.	Rs.	Rs.		Rs.	Rs.	Rs.
Risalewala	1,527	1,485	3,012	2.2	694	675	1,369
Multan	2,098	..	2,098	4.04	520	..	520
Kala Shah Kaku	..	..	4,039	8.80	..	..	454

It will be observed from these figures, that the water-rate per cusec differs considerably from canal to canal. No standard rate has been fixed for the whole of the Province, because it is calculated every 6 months on the earnings of the different canals. As such the rates vary not only from division to division but also from canal to canal in the same division.

Silt in canal water.

Excepting the main canal of the Haveli Project, all other canals of the Punjab are mostly unlined. Owing to the velocity of the water they carry fairly coarse silt. They are designed at such a slope that they silt slightly in the *kharif* when the rivers are in flood and scour to some extent in the winter. They are, therefore, largely self-cleaning.

Losses by percolation.

Owing to percolation through the coarse silt at the bottom of canal beds and through the sides a considerable proportion of the water taken at the head of a canal is lost. This indeed is a very serious problem, because the water lost being valuable could be used for the extension of irrigated areas. Moreover, losses by seepage bring about water-logging and concentration of salts in areas lying near the main canals and branches, especially where the branches take off from the main canal. The amount of this loss has been estimated by various officers of the Irrigation Department from time to time. On the Upper Bari Doab Canal, Mr. Kennedy estimated this loss at 15 per cent. for main canal and 6 per cent. for minors and distributaries. On the Sirhind, Mr. Nicholson confirmed this in general and put the loss at 8 cusecs per million square feet of wetted perimeter. In 1938 on the Lower Kasur Branch the seepage loss was estimated to be about 10½ cusecs per million square feet of wetted surface. On the Lower Chenab Canal total losses were estimated to be about 33 per cent. To save these losses some of the newly constructed canals have been cemented or lined with brick masonry. But this is very costly.

More recently the Punjab Irrigation Research Laboratory at Lahore has found that these losses can be considerably reduced by treating the canal beds with sodium carbonate so as to convert the clay in the bed into soda clay. This method does not involve high expenses. In 1938, 565,870 square feet bed of the Awagat Distributary of the Lower Chenab Canal was treated with the material at a total cost of Rs. 8,000 or Rs. 71 per foot of bed width per mile of length. The results of this experiment have been very encouraging. Observation of the distribution showed that immediately after the treatment there was a saving of 2.3 cusecs of water. Taking the rate at Rs. 1,400 per cusec per annum the total saving in a year may be taken to be Rs. 3,220 nearly.

Water-logging.

Another evil caused by percolation is that of raising of the water-table. In early years of colonization the rate of rise was very high. In 1927 Mr. Lindley examined the rate of the rise of water tables in the Rechna and Chaj Doabs (Punjab Irrigation Branch Paper No. 31-A) and predicted that by 1937 some areas would be water-logged if the same rate of rise continued. But actually water-logged areas were considerably smaller than those forecasts because the rate of rise did not remain constant; on the other hand it decreased. The factor responsible for this decrease is the depth of soil crust. It has been shown by the Irrigation Research Institute that as the water-table approaches the soil crust, the rate of rise decreases and when contact is established with the soil crust the rise ceases. The results also indicate that water-logging is unlikely when soil crust is more than 10′

in thickness, it may occur if the crust is between 10′ and 6′ and it is probable with a crust less than 6 feet. Thus water-logging occurs only in those areas where the soil crust is less than 10 feet in thickness. Even in areas affected by water-logging, portions having soil crust deeper than 10′ stand out like islands.

Another source of water that causes rise in water-table is the rainfall. On account of the construction of field bunds and the blocking of natural drain monsoon rains remain on the soil surface and cause water-logging in low lying areas. This question has been discussed in detail in the Section on "causes of rise of water-table in dry canal tracts" of this chapter.

It is interesting to note that in U.P. where the canal system is considerably developed, no water-logging has been noticed. This is ascribed to the fact that the underground rock ridge runs parallel to the direction of the flow of rivers and thus does not check the natural drainage, whereas in the Punjab the same rock ridge as shown by a Geodetic Survey of the Province runs across the Province at right angles to the direction of the flow of rivers. This ridge thus divides the Punjab into two parts. Upstream of this rock ridge the water table has approached the soil surface and thus caused water-logging whereas downstream of the rock there is no such danger.

Drainage.

Drainage has been advocated as a cure for water-logging and until recently anti-water-logging measures in the Punjab were almost entirely confined to open drainage. This has proved to be effective in checking the damage. It can be safely said that mainly due to maintenance and working extensive systems of drains, *sem* area in the Punjab has not increased to the same extent as was anticipated in the absence of drains. But it must be realised that while drainage is helpful in combating water-logging, it does not do much towards the reclamation of land, affected by *thur*.

In this respect construction of drains has the same effect as other remedial measures, such as tube-well pumping and lining of canals.

Another point worth remembering about the drains is that for the rapid and efficient removal of surface water due to rains and other causes, all the drainage lines (field collecting and other drains) must be kept quite clear of weeds and other obstructions. If the drains get choked with weeds, maximum benefit cannot be gained.

Drains lower the water level in the soil only to a small extent because free water in the soil moves by gravity and its natural direction is downwards. In a field with drains at a depth of say 3 feet, and a water-table at 4 feet depth, no drainage will occur. If water is added on the surface, the water-table rises until it is at the height of the drains, when water will begin to flow into them and drainage occurs. If the field drains are 40 feet apart, the water table in between the drains will be 1½-2 feet only from the surface when the drains practically stop running. If the drains are in working order the water-table remains in motion which in turn provides the amount of oxygen required by the roots of crop and the crops can thus be successfully grown.

With the development of drainage system in the Punjab, the question of the disposal of drainage waters has arisen. With this end in view the examination of waters from the Major Drainage Systems of the *Chaj* and *Rachna* Doabs has been made. In most cases it has been found that the waters have high salt contents and are, therefore, entirely unsuitable to be used as irrigation water. In some cases, however, such as Wan Drainage System and Vagh Nala, water is considered to be quite safe for irrigation. Wherever possible, these waters have been pumped into canals and the mixed waters have been found to be suitable for irrigation.

Kallar or thur.

The earlier soil surveys were all made in areas of high water-table as it was there that the *thur* problem became acute. It was, therefore, believed that the source of the salt responsible for the formation of *thur* was the water-table and that salts appeared as a result of the evaporation of water that is drawn from the water-table to the surface. In subsequent soil surveys which were carried out in the unirrigated tracts of south-west Punjab and the irrigated tracts of the Lyallpur district it was noticed that extensive areas of salt lands existed even when the water-table was as much as 65 to 70 feet from the natural surface. These observations led to further investigations which have now conclusively proved that the formation of salt at the soil surface is due to the presence of salts in the soil crust of first 10 feet from the natural surface and their movements towards the surface when conditions permit these movements. The presence of a high water-table very near the surface accelerates the upward movement of salts to natural surface. Soil surveys have also shown that in the irrigated areas of the Triple Canal Project, the Sutlej Valley and the Haveli Canals there are no less than 2 million acres of land affected by salts in one form or the other and that every year due to the upward movement of salts from the soil crust approximately 30,000 acres of cultivated land become *thur*. The districts in which extensive damage has taken place are Sheikhupura, Gujranwala, Lyallpur, Montgomery, Multan and Jhang.

Reclamation of *kallar* lands.

Depending upon the nature and amount of salts present and the condition of the clay in the soil the deteriorated lands have been classed into two main types—

(*i*) *thur*.

(*ii*) *rakkar*.

In the ***thur*** type are included those lands where the salt-content is high but the process of alkalisation has not progressed very far. The ***rakkar*** types are those in which the salt content may or may not be very high but the degree of alkalisation is considerably high. In this type of land the clay in the soil is extremely alkaline. This type of soil is hard and intractible and more or less impervious to water. ***Bara*** and ***bari*** soils of the Montgomery colony are examples of this type.

The essentials of land reclamation are—

(*a*) The reduction of the salt content of the soil to that considered suitable for normal cultivation.

(*b*) Breaking of soil alkalinity and its reduction to that considered suitable for normal cropping.

The reduction of the salt content in the soil profile is achieved in a field by leaching under heavy irrigation. On account of more frequent irrigations the salts are washed down to depths from where they are unable to rise again to the natural surface.

At a certain stage of leaching rice seedlings are transplanted and the experience shows that rice makes quite a good growth. The introduction of rice during the leaching period is helpful in two ways—

(*i*) Rice roots generate carbon dioxide which in turn helps in breaking the soil alkalinity.

(*ii*) It gives an income to the zemindar during the process of reclamation.

After rice, gram or berseem are sown during the *rabi* following rice. In areas where *rabi* water is available and berseem fodder can be profitably consumed, berseem should always be given preference over gram. Wherever it is not possible to sow berseem, gram should be sown in *wadh-wattar* of rice and matured without any subsequent irrigation. Gram and berseem are leguminous crops. They fix nitrogen in the soil and thus restore the nitrogen balance which is upset during the period of leaching.

The process of reclamation of *rakkar* lands is essentially the same as that described above. The most recent technique developed by the Land Reclamation Department for this type of land is a series of shallow irrigations and shallow ploughings in the initial stage of reclamation. These shallow irrigations and shallow ploughings help in bringing about the upward movement of the salt and its accumulation at the soil surface. With a concentrated salt solution the hard intractible impervious soil assumes a crumby structure which helps in further leaching of the salts, thus bringing about sub-soil drainage and help in the growth of rice. The number of leaching periods and the rice crops required for complete reclamation depends upon the stage of deterioration of the soil. When rice yields are normal and berseem and gram after rice give good yields, it is considered that the land is sufficiently reclaimed. A soil analysis, however, is a sure test. After reclamation sugar-cane, cotton and any other crop can be introduced with confidence.

In certain tracts, however, and that in very small areas applications of gypsum have been found to be beneficial. In considering this it is emphasised that gypsum is unable to react and bring about any results unless and until the excess of salt in the soil has been first removed. For determining the gypsum requirements it is always advisable to get the soils chemically examined and seek the advice of a soil expert.

Causes of rise of water-table in dry canal tracts.

It is difficult to determine exactly the relative effect of percolation from rivers, canal beds and water-courses on the rise of sub-soil water as compared to irrigation in the field and rainfall. Only a brief discussion is possible. The first investigation into the effect of depth of irrigation and rainfall on the rise of water-table was made by Messrs. Wilsdon and Smithy*. These authorities arrived at the conclusion that irrigation affected the water-table since irrigation and rainfall taken together showed definite correlation with the latter. For this reason canal closures were suggested as a means of controlling water table rise. But in view of the fact that irrigation and rainfall represent two different sources of water, the validity of results was questioned and it was decided by the Irrigation Research Institute to carry out a more exhaustive study of the problem which is of immense agricultural importance to this Province. Accordingly investigation into the rise of water-table in the Upper Chenab Canal area was taken in hand. In the *Rachna* Doab the depths of water surface in a large number of wells have been regularly observed in June and October every year and this record kept since 1907. An examination of these figures show that there is a very close association between variations in annual rainfall and variations in

*Punjab Irrigation Research Memories, Vol. I, Nos. 1 and 2.

water-table. Rainfall, therefore, is the dominant factor in the rise of the water-table. This fact is also borne out by the following figures.*

1.	Gross commanded area ..	1,537,658 acres
2.	Total canal discharge utilized in July, August and September,	
	1929 ..	375,737 cusec days
	1930 ..	381,625 do.
3.	Mean daily canal discharge utilized in July, August and September,	
	1929 ..	4,084 cusecs
	1930 ..	4,148 do.
4.	One inch of rainfall over gross area commanded equals ..	64,603 cusecs.
5.	Mean total rainfall over the circle in July, August, and September, (Average 1907–31)	14.80 inches
6.	Rainfall expressed as mean daily discharge for the period July, August and September ..	10,393 cusecs.

In comparison with the irrigation which has often been considered as the main cause of water-table rise the importance of monsoon rainfall is apparent. There is another aspect of the question as well. While irrigation is applied mainly to cultivated area only, the rain falls on all lands, whether cultivated or uncultivated. A part of the rain runs off or evaporates and a part is added to water-table depending upon the contour and nature of land. Evaporation is responsible for the disposal of only a small quantity of rain water. It has also been shown that water that goes to a depth of 10 feet in the soil does not return to the surface. Thus the amount of rain water that is added to

*Irrigation Research Institute Publications, Vol. I, No. 4.

the sub-soil water, depends to a large extent on the run off. It is, therefore important that the run off should be increased as far as possible. Most of our canals run along the slopes of *doabs*, but some of them run across the *doabs*. The latter along with roads and railways cause obstruction to surface drainage of rain water and reduce the run off to a great extent. In order to reduce the effect of rainfall on the sub-soil water, it is of great importance that rain water must be removed as rapidly as possible. This can only be brought about if storm drains are constructed.

Percolation as a factor in rise of water-table.

Taking the Lower Chenab Canal and assuming an over all loss by percolation of 20 per cent. only it means that 2,000 cusecs are constantly being added to the sub-soil water. Two thousand cusecs over a commanded area of three million acres for say 300 days per annum means. 4ft. of water. If there was no flow from the sub-soil this would be sufficient in itself to saturate about 16 feet of soil, if we assume 25 per cent. of the volume of soil is available for water percolation. The authors doubt if this simple factor has been weighed sufficiently by investigators. It is a common observation that water logging generally starts near big channels.

As far as irrigation is concerned, crop itself is an important factor responsible for the disposal of water. A crop like wheat gets about 10-12 inches of water. A considerable portion of it, especially from the *raoni* and *kor* waterings, evaporates from the soil without passing through the plant at all. Assuming this as 25 per cent. or 3 inches, we have 7 to 9 inches left for actual transpiration through the plants. A large number of pot cultures and other tests made at Pusa (India) and in America and elsewhere show that wheat requires from 350 to 700 lbs. of water to pass through the leaves for each pound of dry matter produced. Taking 500 pounds as a conservative figure for a dry place like that of the Punjab, and a yield of 16 maunds grain and 28 maunds bhusa we have a total yield of 44 maunds Deducting 10 per cent. for moisture, we have roughly $39\frac{1}{2}$ maunds of dry matter requiring $39\frac{1}{2}\times500$ maunds or 727 tons of water which is equal to a little more than inches of water per acre. It must be remembered that crops of wheat of 20—30 maunds grain are common. Thus even if allowance is made for rain received in winter, there does not seem to be much room for losses by percolation to the water-table from irrigation applied to crops.

From what has been said above, it will be seen that the construction of storm-water drains, for rapid removal of monsoon rains and checking the seepage of water from canals and their branches appear to be the possible cure of rise of sub-soil water and water logging.

Intensity of cropping

Most of the perennial canals are designed for 50—75 per cent. intensity of cultivation. The farmer can claim this much intensity as a matter of right or *haq* under normal conditions. In 1942-43 on the Lower Chenab Canal the area proposed to be irrigated was fixed at 1,873,378 acres as against 2,870,394 acres of cultivable area commanded. This gives an intensity of about 65 per cent. only. The actual irrigation done is, however, generally 100 per cent. and the zemindar is very much dis satisfied if he cannot reach that figure, which after all only means one crop per annum on his whole area.

The fixing of a low *haq* not only protects Government against failure to fulfil expectations but has in the past undoubtedly acted as an incentive to economy of water through the desire of the zemindar to grow at least one crop per acre per annum. This result has, however, not been obtained merely by economy, for supplies are liberal during the early years of a new canal when all the land has not been brought under cultivation and the percentage of cultivation is approximately 100 from the start, though later this percentage is maintained on a smaller supply of water. Successful colonization would be a difficult matter if the designed percentage of irrigation had been adhered to from the very beginning. Sindh offers a good illustration of this. In that Province the so-called "fallow rules" lay it down that land should be cropped only once in 3 years. In the Jamrao canal the actual irrigation done is only about 45 per cent. The tendency there is to leave a part of the holding permanently fallow and uncultivated, as it would take too much labour to keep it in a clean condition. Weeds flourish in consequence, and the standard of cultivation and of prosperity is very much lower than in the Punjab canals. An intensity of 50 per cent. has been kept on Sukkur Barrage which makes its chances better than that of Jamrao. In Sindh cultivators prefer *kharif* or summer crops but the tendency with low intensity is to go in for *rabi* croppings as in the Punjab canal colonies.

Possibility of increase of intensity of cropping.

In Egypt an intensity of about 160 per cent. is generally obtained and that country has the highest record in the world as regards average yield of cotton. But such a high intensity is possible only where among other things abundant water is available for irrigation throughout the year. On some vegetable growing farms of the Punjab even an intensity of 300 per cent. is obtained. But under general system of farming as is done in the Canal Colonies with the present water supply, an average intensity of more than 100 per cent. is not easy to attain. There is also no possibility of its improvement in the near future. In the winter season there is not enough water in our rivers and with the opening up of the Thal Irrigation Project nearly all our resources of gravitational water in winter will be exhausted. We may then turn to storing of water and increased irrigation from sub-soil water. But such schemes will again be utilized to supply water to those areas which are at present subject to frequent droughts and famines rather than to increase water supply of the existing canal systems.

In summer, river water is abundant but in this part of the year the quantity of water required to mature a crop is nearly double of what it is for winter crops. Thus, if a canal is large enough to take the entire winter water of rivers the ratio of *kharif* crops to *rabi* crops will be about 1: 2. This may be taken to be the natural crop ratio for the canal irrigated areas of the Punjab. But as a matter of fact we have not stopped at this limit; for many past years extensions and enlargements of canals have proceeded beyond the winter-supply point. This means that in winter various canals cannot run full and continuously. Either they must be run partly full or full in rotations. The latter procedure being better, is followed here. This also gives time for carrying out necessary improvements and repairs.

Of all the perennial canals, the Pakpattan canal is worthy of special mention in this connection. Owing to its small share of winter-supply it had been built unusually large to encourage increased use of summer water to make up for small *rabi* irrigation. But this did not prove to be a success, and its winter supply had to be increased *via* Montgomery—Pakpattan link. For happy balance of cultivation, *Kharif* and *Rabi* crops should be kept in proportion. Where well-irrigation is resorted to in winter the percentage of summer crop can be higher.

It may also be noted here that increasing the intensity of cropping through increased *kharif* supplies, will inevitably tend to increase fodder (particularly leguminous) growing. This is clearly shown in the following rotations which have been tried at the Lyallpur Agricultural Farm :—

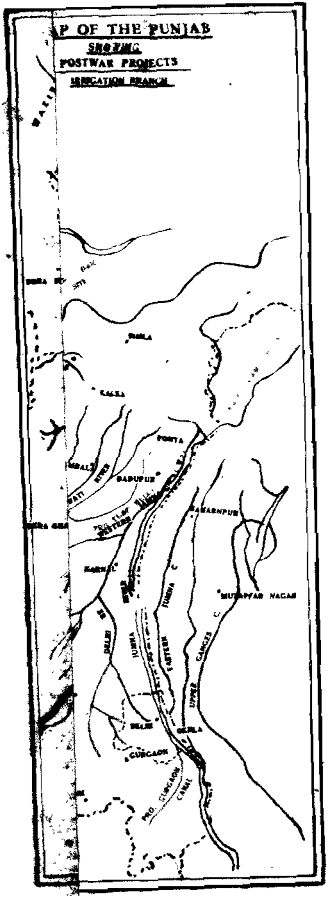
Serial No.	*Intensity Percent.*	*Rotation.*
1	66	Wheat—fallow—cotton.
2	100	Wheat—gram—cotton.
3	133	Wheat—*toria*—cotton—*guara* (green manured).
4	166	Wheat—fodder *chari*—gram cotton—fodder *senji*.

All the above rotations are three-year rotations. In No. 4 there are 2 fodder crops. Increasing the intensity of cropping will inevitably tend to increase fodder growing and thus lead to more cattle being kept and hence more manure being available.

The following new irrigation works are under consideration.—

New Projects

(1) *Thal Project.*—This is a big scheme. The head-works are at Kalabagh on Indus river, and have been


AP OF THE PUNJAB
SHOWING
POSTWAR PROJECTS
IRRIGATION BRANCH
SIMLA
KALKA
PONTA
BADUPUR
SAHARNPUR
KARNAL
MUZAFFAR NAGAR
JUMNA C
JUMNA
EASTERN
UPPER GANGES C
DELHI
OKHLA
GURGAON
PRO. GURGAON CANAL

almost completed. It will command an area of over two million acres. The first portion of this project under construction is Khizar branch and its tributaries, and will cover 495,000 acres gross area. It will commence in *Kharif* 1946. Much of this area already yields rain-fed crops in a year of good rainfall.

(2) *Rasul Hydel Tube-well Project*.—This is designed to irrigate annually about 7 lakhs of acres.

(3) *Jumna Basin.*

(*i*) *Gurgaon Project*.—This canal will take off from tail of Western Jumna canal Delhi Branch, and will irrigate over 4 *lakhs* of acres. Gross commanded area is 418,000 with an annual irrigation of 122,000 acres in Delhi Province and Gurgaon district.

(*ii*) *Kishau Dam Project*.—The dam will be a concrete structure on the Tons river, partly in Sirmour State and partly in United Provinces. It will be 730 feet high and will, therefore, be about the highest dam in the world. Its live storage capacity will be 1.4 million foot acres. The stored supplies will be shared between the Punjab and the U. P. in the ratio of 2:1. The hydro-electric power will also be generated to the extent of 120,000 kilowatts, and will be shared equally between Punjab and U.P. This scheme will provide irrigation facilities to the famine stricken area of Gurgaon, Rohtak and Hissar districts. The cheap hydro-electric power will be used for supplementing irrigation supplies from tube-wells in the upper reaches of the canal, for developing local industries and for rural electrification. The perennial irrigation will be extended to the following area in the Punjab :—

Area	*Gross area acres*	*Annual irrigation acres*
1. Western Jumna Canal extensions (existing)	384,000	115,000
2. Gurgaon Canal	418,000	122,000
3. Barwala Extensions	270,000	97,000

(*iii*) *Giri Dam Project.*—This will be constructed in Sirmour State at Chandni on the Giri tributary of the Jumna river. The height of the dam will be 500 feet. It will have live storage capacity of 0.85 million foot acres. The object of this scheme is to supplement supplies for the annual irrigation of two lakhs of acres in Gurgaon, Rohtak and Hissar districts. The hydro-electric power about 30,000 kilowatts will also be produced. The stored supplies as well as hydel power will be jointly utilised by the Punjab and the U. P. in the same proportion as given for Kishau Dam.

(4) *Sutlej Basin.*

(*i*) *Bist Doab Canal Project.*—This scheme comprises two earthen dams to be built on the Sirsa and Suan tributaries of Sutlej. The dam on the Sirsa tributary would be 126 feet high with a live storage capacity of 246,000 foot acres, and that on the Suan will be 70 feet high with a live storage capacity of 180,000 foot acres. The canal will take off from the right bank of Sutlej at Rupar and will irrigate areas in Hoshiarpur and Jullundur districts, where the sub-soil water table has been falling for some years past, and lifting of water from the wells has consequently become expensive. It will cover a gross area of 500,000 acres with annual irrigation of 180,000 acres.

(*ii*) *Bhakhra Dam Project.*—This dam will be located partly in Bilaspur State and partly in Kangra district. It will be 500 feet high with a live storage capacity of 4 million foot acres. The irrigation water will be utilised in Rohtak, Hissar and Karnal districts of the Punjab, and portions of Patiala, Faridkot, Nabha, Jind and Bikaner States. The gross commanded area will be 4.7 million acres, 3/4th of which will be given perennial and 1/4th non-perennial supplies. Annual irrigation is expected to be 1.5 million acres. 200,000 kilowatts of firm power will be produced for development of industries and rural electrification.

(5) *Chenab and Linked Basins.*

(*i*) *The Dhiangarh Dam-cum-Marhu Tunnel Project.—The Dam.*—This will be a concrete dam, 730 feet in height, with a live storage capacity of 2.5 million foot acres of water. It will also generate about 250,000 Kilowatts of firm power. The object of this project in conjunction with the Marhu tunnel is to increase intensity of irrigation on the five linked canals and extend irrigation to new areas in the Punjab and to some areas in Jammu and Kashmir State, and also to supplement supplies of the Sutlej Valley canals. By readjustment of supplies this scheme may assist the Thal project in critical periods. Cheap power (250,000 Kilowatts) for rural electrification and industrial development will also be made available in addition.

(*ii*) *The Dhiangarh-cum-Marhu Tunnel Project.—The Tunnel.*—This will be located in Chamba State, and will divert about 20,000 cusecs from Chenab into the Ravi river. The diverted supplies will be used for irrigation on Upper Bari Doab Canal and to give relief to the Sutlej Valley Canals during *rabi* and during periods of shortage in early and late *kharif*. This is a most attractive project. In conjunction with the Dhiangarh Dam it has great irrigation and power possibilities.

(*iii*) *Madhopur-Beas Link.*—This project provides for the construction of the channel from above Madhopur Headworks and the Beas, utilising the existing channel of the Chakki torrents as far as possible. It will supplement supplies of the Sutlej Valley Canals and will thus benefit Punjab, and Bahawalpur and Bikaner States.

(*iv*) *Balloki-Sulemanki Link.*—The project comprises a construction of a link from the Ravi to the Sutlej to supplement supplies of the Sutlej Valley Canals in early and late *Kharif*. The quantity of water available in the Ravi during periods of shortage in the Sutlej Valley Canals is small, but with the construction of Dhiangarh Dam-cum-Marhu Tunnel the surplus supplies at Dhiangarh can be transferred to this link, through the Upper Chenab Canal and through the link to the Sutlej Valley Canals, and will thus benefit Punjab and Bahawalpur and Bikaner States.

(6) *Beas Basin.*

(i) *The Larji Dam-cum-Rohtang Tunnel Project.*—

The Dam.—This will be located in Kangra district and Mandi State. It may be constructed as an alternative or in addition to Dhiangarh Dam. It will be a concrete dam 730 feet high with a live storage capacity of 1.7 million foot acres. It will also generate 100,000 K.W. of firm power. The main object of this scheme is to supplement the supplies in Sutlej Valley Canals, as they generally suffer from acute shortage of supplies in *kharif* sowing period, and to a lesser extent in the *kharif* maturing period, and will thus benefit Punjab and Bahawalpur and Bikaner States.

(ii) *The Tunnel.*—This tunnel will be located under the Rohtang pass in the Kangra district, to divert 10,000 cusecs from Chandra arm of the Chenab river into Beas river. A dam about 100 feet high will be necessary for the diversion of supply. The object is to supplement supplies in the Sutlej Valley Canals during sowing and maturing of *kharif* crops, and will benefit the Punjab and Bahawalpur and Bikaner States.

(7) *The Rohtas Reservoir Scheme.*—Under this scheme an earthen dam about 80 feet high is proposed to be constructed on the river Kahn, a tributary of river Jhelum, and will impound 300,000 foot acres of water. The run off of the river Kahn is not enough for contemplated storage. It will have to be supplemented by means of a feeder canal about 10 miles long taken off from the river Jhelum at Mangla. The object of this scheme is to provide irrigation to Jalalpur area or alternatively for increasing the intensity of the five linked canals. It would irrigate 170,000 acres.

(8) *The Tunnel Hydro-electric Project.*—It will be located on Tons tributary of the Jumna river about 40 miles from Dehra Dun, partly in U. P. and partly in Sirmour State. The main object of this project is to generate hydro-electric power. It does not provide for irrigation directly,

Note.—The first two projects, *i.e.*, Thal and Rasul Hydel Tube-well have been sanctioned. The remaining six have not yet been even sanctioned. The figures of culturable commanded area given are provisional. The electric power given is at 73 per cent. load factor.

but the energy (140,000 kilowatts firm power) produced may be used for irrigation by pumping from tube-wells. This scheme is meant to supplement the power development at the Tons and Giri dams if and when the load exceeds the total *output of the latter two stations.*

In addition Government subsidized the construction of 5,000 new wells in 1945 at the rate of 20 per cent of cost or Rs. 300 whichever was less per well. Efforts are also being made in increasing tube-well development and boring of wells.

References

(1) Season and Crops reports of the Punjab.

(2) 'Food production and Well Irrigation' by S. N. Joshi

(3) Handbook of Indian Agriculture by Mukerji.

(4) Reports on the Operations of the Department of Agriculture, Punjab.

(5) Administration Reports of the P.W.D. (Irrigation Branch).

(6) A note on Chinese Agriculture by Sardar Bahadur S. Kartar Singh.

(7) Farm Accounts in the Punjab, 1928-29 to 1937-38, Board of Economic Inquiry publications.

(8) Annual Reports of the Punjab Irrigation Research Laboratories, Lahore.

(9) Punjab Irrigation Branch, paper No. 31-A.

(10) Punjab Irrigation Research Memoirs, Vol. I, Nos. 1, 2 and 4.

(11) Punjab Government answers to questionnaire of the Famine Enquiry Commission and Annexure, 1944.

(12) Irrigation by R. Cecil Wood, Department of Agriculture, Madras, Vol. IV, Bulletin 71 (1917).

(13) Punjab Engineering Congress 1917—Lining of Canals by Mr. T. A. Curry.

(14) Punjab Engineering Congress Report 1918. (Paper by W. Roberts.)

(15) Department of Agriculture, Punjab Leaflets No. 84 and 151.

CHAPTER IX

CAPITAL REQUIRED FOR FARMING AND RETURNS.

The capital required for farming and the returns received will depend on the size of holding and the system of farming as to whether it is *barani*, well-irrigated or canal-irrigated. It will also depend on the intensity of cropping.

The most common unit in the Punjab for a self contained holding is the area which one plough (a pair of bullocks and 2 men) can manage. In case of *barani* area, one plough can control 20—30 acres according to the amount and frequency of rainfall about half of which will be grown under *kharif* crops and the other half under *rabi*. On well-irrigated land as water has also to be lifted in addition to cultivation of the land one pair can control only 5 to 8 acres depending on the depth of water table. The common practice in most of the well-irrigated areas, however, is to cultivate a combined holding, *i.e.*, a part is well-irrigated and a part *barani*. One pair usually manages 2—3 acres on well and 12—15 acres *barani* according to rainfall and depth of water table. Under canal irrigation the area controlled by one pair of bullocks depends on the water supply. In case of Lower Chenab Canal where water is supplied for 75 per cent of the area though actually the entire area is cultivated, one pair can control 10—14 acres, while on Lower Bari Doab Canal where water supply is only for 66 per cent of area and the intensity of cropping is only about 80—90 per cent of the cultivated area, one pair can control 12—16 acres. In case of Nili Bar, the water supply being still less the intensity of cropping is only 80 per cent or even less and one pair often manages one rectangle (25 acres). It must, however, be noted that in case of larger units where 2 or 3 ploughs are jointly working, as is actually the case in several large holdings, larger area can be controlled by a pair. On one square holding 2 ploughs are required but if 2 squares are cultivated as one holding, 3 pairs can manage it well. Thus there is a saving of one pair in case of a bigger holding. In case of one plough holding, 2 permanent men are required but in case of two ploughs 3 men will be enough. Of course, casual labour has to be employed in rush of work such as harvesting and threshing season, sowing time, and for picking cotton.

The bullocks and implements required for 12—14 acres or half a rectangle or square in canal areas and their estimated cost on the average is given below:—

	Rs.	a.
One pair bullocks	300	0
One yoke *panjali*	2	0
Two tying chains (ropes)	1	0
Two chains for *karaha* and *Sohaga* ..	1	0
Desi plough	4	8
Two *jhuls*	4	0
Daranti (2) @ annas 8 each	1	0
Khurpas (2) @ annas 8 each	1	0
Kasi (2) @ Rs. 1-8 each	3	0
Karah	3	0
Trangli	1	8
Sanga	1	0
Phalla	0	8
Chhaj (2)	0	12
Sohaga	4	0
Phaora	0	6
Kulhari	0	12
Jandra	1	0
Toka	1	0
Baskets (2)	0	8
Chhiklis (2)	0	12
Gandala (1)	0	12
Balti (1)	1	4
Tangar (1)	2	0
Kasola (1)	0	12
Baguri (1)	0	10
Total ..	338	0

In addition to above the cultivator would require one milch animal with one or two young stocks, valued at Rs.150. Thus the total capital required is about Rs. 488. Some building will also be needed for housing the cultivator's family, his livestock and dead stock. These are generally made locally and may be taken to cost about Rs. 250 as cultivator himself supplies the labour. On newly cultivated land where wood is available, the cost may be less. Besides some household articles will also be needed for domestic needs. These are spinning wheel, hand gin, utensils, boxes for stores, etc., costing in all about Rs. 50.

Further, some money will be required for the maintenance of bullocks and the family before the first crop is gathered. This may be taken at Rs. 200.

The total capital required for starting cultivation for a one plough-holding on canal colony will thus amount to :—

	Rs.
(1) Bullocks and implements	338
(2) Milch animals	150
(3) Buildings	250
(4) Household articles	50
(5) For maintenance till first crop is secured	200
Total ..	988
Or say about ..	1,000

In case of two plough-holding cultivating a square or rectangle, some extra implements will be needed. These are:—

	Rs.
Cart	100
Chaff-cutter	40
Total ..	140

These are not absolutely essential at first.

For well-irrigated area the following additional capital is required :—

	Rs.	a.
Cost of well (Depth—25 feet) ..	750	0
Cost of Persian wheel	120	0
Extra pair of bullocks	300	0
Two more yokes: 1 for well and 1 for plough	4	0
One large *sohaga*	7	0
One plough	4	8
Two more *jhuls*	4	0
Two more chains	1	0
Total ..	1,190	8
or Say ..	1,200	0

For *barani* area the capital required is about the same as on canal-irrigated land but one plough can manage 20—30 acres as already stated according to intensity of cropping which depends on rainfall.

Gross returns, expenditure, and net returns.

The usual cropping under different conditions of farming are given in Chapter VII. The gross income, expenditure and net returns for some important types of arable farming is given below. It must be stated that in these calculations, average yields have been taken into account but a good farmer is not satisfied with average yield and expects much higher yields. Under such conditions profits increase very much because there is not proportional increase in expenses.

(1). Income and expenditure of a one-square farm in the Lower Chenab Canal Colony

Area held—28 acres
Intensity of cropping—97 per cent.
Permanent family workers—2
Hired worker—1.

GROSS RETURN

Crop	Area	Product	Yield per acre	Total yield	Price per *maund*	Value
	Acres		*Mds.*	*Mds.*	Rs. a.	Rs. a. p.
Wheat ..	11·0	Grain	13·6	149·6	2 9	383 5 7
		Bhusa	21·0	231·0	0 7	101 1 0
Cotton American ..	4·0	*Kapas*	6·2	24·8	9 5	230 15 2
		Sticks	..	..	1 0 per acre	4 0 0
Cotton *Desi* ..	1·0	*Kapas*	6·0	6·0	8 2	48 12 0
		Sticks	..	..	1 0 per acre	1 0 0
Sugarcane ..	1·0	*Gur*	26·9	26·9	5 3	139 8 8
Maize ..	1·0	Grain	13·4	13·4	2 8	33 8 0
		Stalks	..	..	3 0 per acre	3 0 0
Toria ..	2·5	Seed	6·6	16·5	4 2	68 1 0
Gram ..	2·0	Grain	8·7	17·4	2 6	41 5 2
		Bhusa	9·0	18·0	2 0	36 0 0
Kharif fodders ..	2·5	..	..	..	32 0	80 0 0
Rabi fodders ..	2·0	..	..	..	40 0	80 0 0
Total ..	**27·0**	..	..	..	..	**1,250 8 7**

EXPENDITURE

		Rs. a. p.	Rs. a. p.	Rs. a. p.
1. *Manual labour* (*i*) *hired*—				
Permanent—one at the following per annum—				
Cash Rs. 5 per mensem	..	60 0 0		
One *maund* wheat per mensem for meals=12 *maunds* at Rs. 2/9/- per *maund*	..	30 12 0		
				90 12 0
(*ii*) *Casual*—				
(*i*) Harvesting wheat.				
4 acres at 4 bundles per acre =16 bundles.				
Each bundle:				
Grain 16 *seers* at Rs. 2/9/- per *maund*	..	1 0 5		
Bhusa 24 seers at As. 7 per *maund*	..	0 4 2		
Total	..	1 4 7		
Value of 16 bundles	..		20 9 4	
(*ii*) Winnowing wheat 135 *mds*. At 2 seers per *md*=6.75 *mds*. At Rs. 2/9/- per *maund*	..		17 4 9	
(*iii*) Cotton picking at 1/10th of the total produce.				
American *Kapas* 2.5 *mds*. @ Rs. 9/5/- per *maund*	..	23 4 6		
Desi kapas 0.6 mds. at Rs. 8/2/- per *maund*		4 14 0	28 2 6	
(*iv*) Sugarcane: *Gur* to *Jhoka* at 1 seer per *maund*=27 seers at Rs. 5/3/- per *maund*	..		3 8 0	
(*v*) Miscellaneous	..		4 0 0	
				73 8 7
2. *Bullock labour*—				
Roughages consumed by all stock				
Green fodders	..	160 0 0		
Bhusa 150 mds. at As. 7 per *maund*		65 10 0		
Maize stalks	..	3 0 0		
Total	..	228 10 0		

	Rs.	a.	p.	R.	a.	p.
Total stock on the farm 8						
Bullocks 4						
Bullocks' share of roughages ½ ..	114	5	0			
Concentrates 15 *mds.* at Rs. 3 per md.	45	0	0			
Salt 20 *seers* at Rs. 2/8/- per *maund*	1	4	0			
Miscellaneous feeds ..	4	0	0			
Interest at 4 per cent. and depreciation at 12 per cent on Rs. 300 ..	48	0	0			
Miscellaneous expenses ..	10	0	0			
				222	9	0
4. *Seeds*—						
Wheat ..	18	2	5			
Cotton American ..	1	3	2			
Cotton *Desi* ..	0	3	2			
Sugarcane ..	8	0	0			
Maize ..	0	8	10			
Toria ..	0	10	6			
Gram ..	2	0	0			
Kharif fodders ..	3	12	0			
Rabi fodders ..	6	0	0			
				40	8	1
5. *Implements*—						
Depreciation at 10 per cent. on cart= Rs. 100 ..	10	0	0			
20 per cent. on fodder cutter=Rs. 40	8	0	0			
Interest at 4 per cent. on Rs. 140 ..	5	9	7			
Rent of cane crusher ..	4	0	0			
Miscellaneous repairs and replacement	6	0	0	33	9	7
6. *Artisans* (Carpenter and Blacksmith).						
Wheat bundles 4 at Re. 1/4/7 each ..	5	2	4			
Wheat 1 *maund* at Rs. 2/9/- per *maund*	2	9	0			
Maize bundles 2 at As. 10 each ..	1	4	0			
Maize 1 *maund* at Rs. 2/8/- per *maund*	2	8	0			
Gur 4 *seers* at Rs. 5/3/- per *maund* ..	0	8	4			
Cotton 4 *seers* at Rs. 8/2/- per *maund*	0	13	0			
Fodders 6 bundles at As. 3 each ..	1	2	0	13	14	8
7. *Water rates*—				116	6	0
8. *Land Revenue*—				135	0	0
Total ..				726	3	11

SUMMARY

	Total Rs.	a.	p.		per acre Rs.	a.	p.
Gross income ..	1,250	8	7	.. ..	44	10	7
Expenditure ..	726	3	11	.. ..	25	15	0
Net income ..	524	4	8	.. ..	18	11	7

(2). Income and Expenditure of one rectangle farm in the Lower Bari Doab Canal Colony.

Area held	..	.. 25 acres.
Intensity of cropping	..	.. 92 per cent.
Permanent family workers	..	.. 2
Permanent hired workers	..	.. 1

GROSS INCOME

Crop	Area	Product	Yield per acre	Total yield	Price per *maund*	Value
	Acres		*Mds.*	*Mds.*	Rs. a.	Rs. a. p.
Wheat ..	8·0	Grain	12·6	100·8	2 9	258 4 10
		Bhusa	19·0	152·0	0 7	66 8 0
Cotton American ..	6·0	*Kapas*	8·7	52·2	9 5	486 1 10
		Sticks	..	..	1 0 per acre	6 0 0
Cotton *Desi* ..	0·5	*Kapas*	7·3	3·7	8 2	30 1 0
		Sticks	..		1 0 per acre	0 8 0
Sugarcane ..	0·5	*Gur*	25·5	12·8	5 3	66 6 5
Maize ..	1·0	Grain	8·7	8·7	2 8	21 12 0
		Stalks	..	..	3 0 per acre	3 0 0
Toria ..	1·0	Grain	5·3	5·3	4 2	21 13 10
Gram ..	2·0	Grain	8·3	16·6	2 6	39 6 10
		Bhusa	8·0	16·0	0 2	2 0 0
Kharif fodders ..	2·0	..	..	..	32 0 per acre	64 0 0
Rabi fodders ..	2·0	..	..	..	40 0 per acre	80 0 0
Total ..	23·0	..	..	..	..	1145 14 9

EXPENDITURE

		Rs. a. p.	Rs. a. p.
(1) *Manual labour*—			
(*a*) Permanent—			
The same as in the case of L. C. C. C. ..		..	90 12 0
(*b*) Casual—			
(*i*) Harvesting wheat 2 acres each at 4 bundles per acre—8 bundles at Re. 1/4/7 each ..		10 4 8	
(*ii*) Winnowing wheat 92 *maunds* at 2 *seers* per *maund*=4.6 *mds*. at Rs. 2/9/- per *maund* ..		11 12 7	
(*iii*) Cotton picking 1/10th share.			
American *Kapas* 5.2 *maunds* at Rs. 9/5/- per *md*.		48 6 10	
Desi kapas 0.4 *maund* at Rs. 8/2/- per *maund* ..		3 4 0	
(*iv*) Sugarcane *Gur* to *Jhoka* at 1 seer per *maund* =13 *seers* at Rs. 5/3/- per *maund* ..		1 11 0	
(*v*) Miscellaneous		4 0 0	79 7 1
2. *Bullock labour*—			
Roughages consumed by all stock :			
Green fodders	144 0 0		
Bhusa 145 *mds*. at As. 7 per *maund* ..	63 7 0		
Maize stalks	3 0 0		
Total ..	210 7 0		
Total stock on the farm—8			
Bullocks 4			
Bullock's share of roughages ½ ..	105 3 6		
Concentrates 15 *mds*. at Rs. 3 per *maund*	45 0 0		
Salt 20 *seers* at Rs. 2/8/- per *maund* ..	1 4 0		
Miscellaneous feeds	4 0 0		
Interest at 4 per cent. and depreciation at 12 per cent. on Rs. 300	48 0 0		
Miscellaneous expenses	10 0 0		
..			213 7 6
3. *Seed*—			
Wheat		13 3 2	
Cotton American		1 12 10	
Cotton *Desi*		0 1 7	
Sugarcane		4 0 0	
Maize		0 8 10	
Toria		0 4 3	
Gram		2 0 0	
Kharif fodders		3 0 0	
Rabi fodders		6 0 0	
			30 14 8
4. Implements: The same as in the Lower Chenab Canal Colony except that the rent of the cane crusher will be Rs. 2 instead of Rs. 4			31 9 7
5. Artisans the same as in the case of Lower Chenab Canal Colony			13 14 8
6. Water rates			98 10 0
7. Land Revenue			92 0 0
Total ..			650 11 6

SUMMARY

		Total	Per Acre
		Rs. a. p.	Rs. a. p.
Gross Income	..	1,145 14 9	45 13 5
Expenditure	..	650 11 6	26 0 6
Net Income	..	495 3 3	19 12 11

(3) Income and expenditure of a *Chahi*-cum-*barani* farm in the Jullundur District.

Area held 16 acres .. { Well irrigated = 8 acres. *Barani* = 8 acres.

Permanent workers .. { *Family* .. 2 Hired .. Nil.

GROSS INCOME.

Crop	Area	Product	Yield per acre	Total yield	Price per *maund*	Value
Well irrigated—	Acres		*Mds.*	*Mds.*	Rs. a.	Rs. a. p.
Cotton *Desi* ..	0·5	*Kapas*	8·4	4·2	7 0	29 6 5
		Sticks	..	..	2 0 per acre	1 0 0
Maize ..	1·0	Grain	17·4	17·4	2 9	44 9 5
		Stalks	..	..	6 0 per acre	6 0 0
Sugarcane ..	1·0	*Gur*	36·5	36·5	5 5	193 14 6
Wheat ..	4·0	Grain	14·5	58·0	2 11	155 14 0
		Bhusa	22·0	88·0	0 10	55 0 0
Kharif Fodders	1·5	..	..	..	40 0	60 0 0
Rabi Fodders ..	1·5	..	..	..	50 0 per acre	75 0 0
Total ..	9·5	..	..	..	..	620 12 4
Barani—						
Wheat ..	3·0	Grain	7·7	23·1	2 11	62 1 4
		Bhusa	10·0	30·0	0 10	18 12 0
Chari (Fodder)	5·0	..	..	..	15 0 per acre	75 0 0
Total ..	8·0	..	..	..	..	155 13 4
Grand Total ..	17·5	..	..	..	..	776 9 8

EXPENDITURE

	Rs. a. p.	Rs. a. p.
1. *Manual labour*—		
(*a*) Permanent hired—nil.		
(*b*) Casual		
(*i*) Harvesting wheat.		
Irrigated area—		
4 bundles each valued as follows:—		
Wheat grain 16 *seers* at Rs. 2/11/- per *maund* ..	1 1 2	
Wheat *bhusa* 24 *seers* at Re. -/10/- per *maund* ..	0 6 0	
Total ..	1 7 2	
Value of 4 bundles	5 12 8	
Unirrigated area—		
4 bundles each valued at Rs. 1/7/2 each ..	5 12 8	
(*ii*) Winnowing wheat.		
Irrigated area.		
2·6 *mds.* wheat at Rs. 2/11/- per *maund* ..	6 15 10	
Unirrigated area.		
0·85 *maunds* wheat at Rs. 2/11/- per *maund* ..	2 4 7	
(*iii*) Cotton picking (irrigated).		
1/10th share=0·4 *mds.* at Rs. 7 per *maund* ..	2 12 10	
(*iv*) Sugarcane (irrigated).		
Gur to *Jhoka* at 1 *seer* per maund=37 *seers* at Rs. 5/5/- per *maund*	4 14 8	
(*v*) Miscellaneous. (Rs. a. p.)		
Irrigated area 2 0 0		
Unirrigated area 1 0 0	3 0 0	
		31 9 3
2. *Bullock labour*—		
Roughages consumed by all stock on the farm.		
Green fodder	210 0 0	
Bhusa 118 *mds.* at As. 10 per *md.*	73 12 0	
Maize stalks	6 0 0	
	289 12 0	
Total stock—8·0 animals.		
Bullocks—4·0 animals.		
Bullocks' share of roughages ½	144 14 0	
Concentrates 24 *mds.* at Rs. 3 per *maund* ..	72 0 0	
Salt 20 *seers* at Rs. 2/8/- per *maund*	1 4 0	
Miscellaneous feeds	4 0 0	
Interest at 4 per cent. and depreciation at 12% on Rs. 300	48 0 0	
Miscellaneous expenses	10 0 0	
		280 2 0
3. *Seed*—		
Irrigated		
Cotton .. 0 1 7		
Maize .. 0 6 7		
Sugarcane .. 8 0 0		
Wheat .. 7 3 2		
Kharif Fodders .. 2 4 0		
Rabi Fodders .. 4 5 0		
	22 4 4	
Unirrigated—		
Wheat .. 5 6 5		
Ohari .. 7 8 0		
	12 14 5	35 2 9

		Rs. a. p.	Rs. a. p.
4.	*Implements—*		
	Depreciation at 10 per cent. on cart worth Rs. 100.	10 0 0	
	Depreciation at 20 per cent. on fodder cutter worth Rs. 40	8 0 0	
	Interest at 4 per cent. on Rs. 140	5 9 7	
	Hire of cane crusher	4 0 0	
	Repairs etc.	6 0 0	
			33 9 7
5.	*Artisans—*		
	Wheat 1 *maund* at Rs. 2/11/- per *maund* ..	2 11 0	
	Maize 1 *maund* at Rs. 2/9/- per *maund* ..	2 9 0	
	Wheat bundles 4 at Rs. 1/7/2 each	5 12 8	
	Maize bundles 4 at As. 10 each	2 8 0	
	Gur 4 *seers* at Rs. 5/5/- per *maund*	0 8 6	
	Cotton 4 *seers* at Rs. 7/4/- per *maund*	0 11 7	
	Fodder bundles 8 at As. 3 each	1 8 0	
			16 4 9
6.	*Well and Persian Wheel—*		
	Depreciation at 3 per cent. on well worth Rs. 750..	22 8 0	
	25 per cent. on chain of Persian Wheel worth Rs. 40	10 0 0	
	10 per cent. on other parts of Persian Wheel worth Rs. 80	8 0 0	
	Interest at 4 per cent. on Rs. 870	34 12 10	
	Repairs and replacements	2 0 0	
	Oil for lubrication	6 0 0	
7.			83 4 10
	Land Revenue—		
	Irrigated area	32 0 0	
	Unirrigated area	16 0 0	48 0 0
	TOTAL	..	528 1 2

ANALYSIS OF EXPENDITURE

Item	TOTAL			PER ACRE		
	Total	Irrigated	Un-irrigated	Total	Irrigated	Un-irrigated
	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
Manual Labour (hired)	31 9 3	22 8 0	9 1 3	1 15 7	2 13 0	1 2 2
Bullock labour	280 2 0	210 1 6	70 0 6	17 8 1	264 4 2	8 12 1
Seed ..	35 2 9	22 4 4	12 14 5	2 3 2	2 12 6	1 9 9
Implements ..	33 9 7	25 3 2	8 6 5	2 1 7	3 2 5	1 0 10
Artisans ..	16 4 9	12 3 7	4 1 2	1 0 4	1 8 5	0 8 2
Well and Persian Wheel	83 4 10	83 4 10	.. .. ..	5 3 4	10 6 8	.. .. ..
Land Revenue	48 0 0	32 0 0	16 0 0	3 0 0	4 0 0	2 0 0
Total ..	328 1 2	407 9 5	120 7 9	33 0 1	50 15 2	15 1 0

SUMMARY

	Total			Per acre		
	Total	Irrigated	Unirrigated	Total	Irrigated	Unirrigated
	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p
Gross Income ..	776 9 8	620 12 4	155 13 4	48 8 7	77 9 6	19 7 8
Expenditure ..	528 1 2	407 9 5	120 7 9	33 0 1	50 15 2	15 1 0
Net Income....	248 8 6	213 2 11	35 5 7	15 8 6	26 10 4	4 6 8

(4) Accounts of a *barani* Farm in the **Hissar** District.
Area held .. .. 30 acres.
Intensity of cropping .. 100 per cent.
Permanent workers, Family—2.

GROSS INCOME

Crop	Area	Produce	Yield per acre	Total yield	Price per *maund*	Value
	Acres		*Mds.*	*Mds.*	Rs. a. p.	Rs. a. p.
Guara ..	2·0	Grain	3·0	6·0	2 4 0	13 8 0
		Bhusa	3·0	6·0	0 4 0	1 8 0
Moth and *Bajra* ..	3·0	*Moth* grain	0·5	1·5	2 4 0	3 6 0
		Bajra grain	2·0			
		Stalks and	6·0	6·0	2 8 0	15 0 0
		Bhusa	..	15·0	0 4 0	4 8 0
Guara (fodder) ..	3·0		..	..	5 0 0 Per acre	15 0 0
Jowar (fodder) ..	4·0		..	..	4 0 0 Per acre	16 0 0
Gram ..	3·0	Grain	5·3	15·9	2 12 0	43 11 7
		Bhusa	5·3	15·9	0 4 0	3 15 7
Wheat ..	6·0	Grain	5·5	33·0	2 15 0	96 15 0
		Bhusa	7·2	43·2	0 7 0	18 14 5
Taramira ..	2·0	Seed	3·0	6·0	2 0 0	12 0 0
Gram-barley ..	7·0	Grain	5·8	40·6	2 8 0	101 8 0
		Bhusa	6·5	45·5	0 6 0	17 1 0
Total ..	30 0					362 15 7

EXPENDITURE

1. *Manual labour (hired)*—			Rs. a. p.
Casual			3 0 0
2. Bullock labour—			
Total live-stock on the farm—4·0 animals.			
Roughages fed to all stock.		Rs. a. p.	
Guara bhusa		1 8 0	
Moth bajra stalks and *bhusa*		4 8 0	
Gram *bhusa*		3 15 7	
Wheat *bhusa*		18 14 5	
Gram barley *bhusa*		17 1 0	
Green fodder		31 0 0	
	Total	76 15 0	
No. of working animals—Bullocks—2.			
Working animals' share of roughages ½		38 7 6	
Concentrates 7 *maunds* at Rs. 3 per *maund* ..		21 0 0	
Salt 10 *seers* at Rs. 2/8/- per *maund*		0 10 0	
Interest at 4 per cent. and depreciation at 12 per cent. on Rs. 150		24 0 0	
			84 1 6
3. *Seed*—			
Guara		4 8 0	
Moth		0 4 0	
Bajra		0 9 11	
Jowar		6 0 0	
Gram		7 5 7	
Wheat		11 11 2	
Taramira		0 5 5	
Barley		5 8 2	
			36 4 3
4. *Implements*—Repairs			1 4 0
5. *Artisans*—			
Guara 2 *seers* at Rs. 2/4/- per *maund*		0 1 10	
Bajra 2 *seers* at Rs. 2/8/- per *maund*		0 2 0	
Gram barley 1 *maund* at Rs. 2/8/- per *maund* ..		2 8 0	
Fodder 2 bundles at As. 3 each		0 6 0	
			3 1 10
6. *Land Revenue*—			7 8 0
	Total ..		135 3 7

SUMMARY

	Total Rs. a. p.	Per acre Rs. a. p.
Gross Income	362 15 7	12 1 7
Expenditure	135 3 7	4 6 1
Net Income	227 12 0	7 9 6

(5) Income and Expenditure of a one rectangle farm in the Nili Bar Canal Colony.

Area held	.. ..	.. 25 acres.
Intensity of cropping	..	.. 72 per cent.
Permanent family workers	..	.. 2
Permanent hired workers	..	.. Nil.

GROSS INCOME

Crop	Area	Product	Yield per acre	Total yield	Price per *maund*	Value
	Acres		*Mds.*	*Mds.*	Rs. a. p.	Rs. a. p.
Wheat ..	8·0	Grain	12·9	100·8	2 9 0	258 4 10
		Bhusa	19·0	152·0	0 7 0	66 8 0
Cotton American ..	5·5	*Kapas*	8·7	47·9	9 5 0	446 1 1
		Sticks	..	..	1 0 0	5 8 0
Cotton *desi* ..	0·5	*Kapas*	7·3	3·7	8 2 0	30 1 0
		Sticks	..	..	1 0 0	0 8 0
Kharif Fodders ..	2·0	..	..	..	32 0 0	64 0 0
Rabi Fodders ..	2·0	..	..	..	40 0 0	80 0 0
Total ..	18·0					950 14 11

EXPENDITURE

	Rs. a. p.	Rs. a. p.
1. **Manual** labour hired—		
(*a*) Permanent—nil.		
(*b*) Casual—		
Harvesting wheat 6 acres at 4 bundles per acre= 24 bundles, each bundle at Rs. 1/4/7 each ..	30 14 0	
Winnowing 92 *maunds* wheat at 2 *seer* per *maund* = 4·6 *maunds* at Rs. 2/9/- per *maund*	11 12 7	
	42 10 7	
Cotton picking 1/10th share American *kapas* 4·8 *maunds* at Rs. 9/5/- per *maund*	41 14 6	
Desi kapas 0·4 *maunds* at Rs. 8/2/- per *maund* ..	3 4 0	
Miscellaneous	2 0 0	
		89 13 1
2. *Bullock labour*—		
Roughages consumed by all stock—		
Wheat *bhusa* 130 *maunds* at As. 7 per *maund* ..	56 14 0	
Green fodders	144 0 0	
Total ..	200 14 0	

	Rs. a. p.	Rs. a. p.
Total stock on the farm=6		
Bullocks =2		
Bullocks' share of roughages ½	66 15 4	
Concentrates 10 *maunds* at Rs. 3 per *maund*	30 0 0	
Salt 10 seers at Rs. 2/8/- per maund	0 10 0	
Miscellaneous feeds	2 0 0	
Interest at 4 per cent. and depreciation at 12 per cent. on Rs. 150	24 0 0	
Miscellaneous expenses	5 0 0	
		128 9 4
3. *Seeds*—		
Wheat	13 3 2	
Cotton American	1 10 5	
Cotton *desi*	0 1 7	
Kharif fodders	3 0 0	
Rabi fodders	6 0 0	
		23 15 2
4. *Implements*—		
Depreciation at 10 per cent. on cart=Rs. 100	10 0 0	
At 20 per cent. on fodder cutter=Rs. 40	8 0 0	
Interest at 4 per cent. on Rs. 140	5 9 7	
Miscellaneous repairs and replacements	6 0 0	
		29 9 7
5. *Artisans* (Carpenter and Blacksmith)		
Wheat bundles 6 at Rs. 1/4/7 each	7 11 6	
Wheat 2 *maunds* at Rs. 2/9/- per *maund*	5 2 0	
Cotton 4 *seers* at Rs. 8/2/- per *maund*	0 13 0	
Fodder 6 bundles at As. 3 each	1 2 0	
		14 12 6
6. *Water Rates*—		55 8 0
7. *Land Revenue*—		72 0 0
Total		414 3 8

SUMMARY

	Total Rs. a. p.	Per Acre Rs. a. p.
Gross Income	950 14 11	38 0 7
Expenditure	414 3 8	16 9 1
Net Income	536 11 3	21 7 6

References

1. Farm Accounts in the Punjab—Board of Economic Inquiry Publications.

CHAPTER X

WEEDS

A plant out of its proper place may be technically called a weed, but from the farmer's point of view only that plant is a weed which is injurious to crops, or is unsightly and troublesome in agricultural operations.

Annual losses due to the occurrence of pernicious weeds upon farm lands, though acknowledged in a general way, are far greater than are realised. The figures would be alarming if these losses be interpreted in terms of money for the whole country. The extent of their occurrence may be judged from the fact that as many as 30 different weeds have been recorded in one crop. The weeds are harmful to crops in several ways as shown below:—

(1) They rob the soil of plant food and moisture.
(2) Being hardier than many of the garden and field crops, they crowd out the useful plants.
(3) Work in their eradication increases the cost of cultivation.
(4) Weeds like *pohli* and *kandiari*, in wheat, cause harvesting difficulties. Some tenancious weeds like *baru* and *kahi* get such a firm hold on the soil that cultivation on them becomes impossible.
(5) Weeds harbour insect and fungus pests which attack the crops.
(6) The presence of weed seeds in agricultural produce reduces its market value.

These losses can be considerably lessened by treatment based on the accurate knowledge of the nature, habit of growth and modes of dissemination of each weed.

General principles of eradication of weeds.

In eradication of weeds it is important to know the class to which a certain weed belongs, for in case of annual and biennial weeds the treatment is usually to prevent them from seeding, while in case of perennial weeds the formation of new leaves and roots and underground stems is also to be restricted and if possible stopped. It is, thus, essential to know the habit of growth, as well as, time of germination and ripening. Specific treatment for eradication of important weeds will be given along with their description. The general principles are, however, given below:—

(1) Never allow weeds to ripen seeds, for we know: "One year's seeding, seven years' weeding".

Weeds produce large number of seeds as shown below:—

(*i*) Conyza (*daryai buti*)	..	Over	54,000
(*ii*) Corchorus (*jangli jut*)	..	„	12,000
(*iii*) Sida (*bala*)	..	„	12,000
(*iv*) Solanum nigrum (*makoh*)	..	„	10,000
(*v*) Cleome sp. (*hulhul*)	..	„	13,000

(2) All weeds bearing mature seeds should be burnt or thrown in places from which they cannot be carried easily to fields by wind, water or animals. Sometimes, such weeds are fed to cattle and the refuse is taken to the manure heaps, from where they find their way to the fields. Manure containing such weed seeds should never be applied fresh.

(3) Be always on the alert to prevent new weeds from becoming established.

(4) Use always clean seed—this is very important.

(5) Efforts for eradication of perennial weeds should be persistently made. Imperfect treatment such as a single ploughing may do harm instead of good by breaking underground stems and stimulating their growth. The best method of removing them is to plough the land deeply in summer and expose the underground parts to the sun. It will also be useful to collect and

burn them. Hoeing and interculture during the growth of the crop is very helpful in keeping down weeds. These operations are facilitated if crops are sown in lines.

(6) Waste places, borders of fields and water channels should be kept clear of weeds to prevent contamination of the cultivated areas.

(7) In the case of some weeds like *piazi*, *itsit* and such other annuals, which come up quickly, the practice called *dab* is very effective. This consists in preparing the land for sowing and leaving it for sometime before it is actually sown. The weed seeds will germinate during this interval and are uprooted during sowing operations.

In some foreign countries chemicals are being used as weed killers. In India they must be employed with care as some of them are poisonous, and are not safe in the hands of the ordinary illiterate farmers. Moreover, they are very expensive. The most important of them are:—

Common salt (sodium chloride)	5 per cent. solution of it in water destroys small weeds.
Copper sulphate	3 per cent. solution.
Iron sulphate	15—20 per cent. solution.
Sodium chlorate	10 per cent. solution.
Sodium arsenite	1 lb. white arsenic in a solution of 1 lb. washing soda in 3 gallons of water.

Premex, a patent preparation, has been found very effective against leafy weeds; 2 per cent. solution is sufficient to kill them.

Some weeds can also be controlled by insects and fungus pests. Cochineal insect (*Dactylopius tomentosus*) which lives on prickly pear—a cactus, has been found to be very effective in controlling this plant at Jullundur.

In some countries, destruction of weeds has been made compulsory by legislation and failure to eradicate them is punished with a fine or imprisonment. There is such legislation in Madras and Baroda against insect and fungus pests. A bill on the same lines both for weeds as well as insect and fungus pests is under the consideration of the Punjab Government.

Classification of weeds.

(*a*) According to the length of time they live, weeds are divided into three classes:—

(1) Annual weeds which live for one year only, as *pohli*, *piazi*, and *bathu*.

(2) Biennial weeds which live for two years. There is no typical example of these weeds in the Punjab.

(3) Perennial weeds which live for more than two years, as *dub*, *baru*, *dabh* grasses, *lehli*, *motha*, and *leh*. They are difficult to eradicate. Besides producing seeds, they possess thick underground parts from which they grow again, after the aerial parts die in winter.

(*b*) According to the season in which they grow, the weeds are known as *kharif* weeds and *rabi* weeds :—

1. *Kharif* weeds are those that grow during summer, *i.e.*, from April to September, *e.g.*, *motha*, *baru* and *kutta* grass.

2. *Rabi* weeds are those the growing period of which extends from September to April, *i.e.*, during winter as *piazi*, *bathu* and *pohli*.

Kharif weeds.

1. *Dub* or *Khabbal*, *Talla* (*Cynodon dactylon*).—

Natural Order—*Gramineæ*.

Dub grass is found in all soils excepting very light ones. In rich soils, however, its growth is very luxuriant. Its presence generally indicates that the soil on which it is growing is good. It is considered to be the best fodder grass for all class of domestic animals, specially for horses. When made into hay it keeps well and is a good fodder. It is perennial but growth ceases in severe winter months.

Method of eradication.—Land badly infested with this grass should be put under wheat for a year or more. Cultivation required for wheat will destroy *dub* grass. Furrow turning ploughs are more effective for this purpose than *desi* plough. They should not be worked deeper than 4 inches, so that the roots may be exposed and not buried in the soil. If possible uprooted grass should be taken out of the soil by hand or by use of harrows. This weed or grass is extensively used for grass lawns.

2. *Baru* grass (*Sorghum halepense*).—Perennial.

Natural Order—*Gramineæ*.

It is a tall perennial grass with creeping rhizomes which throw up many shoots. Its growth is checked in winter. It is found on both light and heavy, and on cultivated and uncultivated soils. It is used as a fodder for cattle, but is said to be poisonous when quite young, or, if subjected to drought, on account of the presence of hydrocyanic acid. No such injurious effects are, however, reported from Australia or United States of America, where it is also used as a fodder.

Eradication.—On account of its vigorous underground stems (rhizomes) it is a very hard weed to eradicate. A single ploughing will stimulate its growth by breaking underground stems, and, thus, increasing the number of plants. Persistent efforts should be made to combat this pernicious weed. Iron ploughs should be worked as deep as possible. The spade will have to be used in some cases. All the underground stems brought up by cultivation should be collected and burnt when dry, otherwise some of them are likely to strike roots again. Its above ground stems should not be allowed to mature seed even if the destruction of under ground parts cannot be taken up at once. This will check its further spreading by seed.

Eradication of *baru* should be taken up at its first appearance. It requires a lot of labour and time to eradicate if *baru* is allowed to establish itself on the land. Efforts at eradication must be continued persistently until the land is quite clean.

3. *Dabh* or *kussa* grass (*Eragrostis cynosuroides*).—Perennial.

Natural Order—*Gramineæ*.

It is a perennial grass with thick rhizomes. It is abundant in all kinds of soils, and especially in low lying *usar* lands, or *bet* and *hithar* lands near the rivers. It is not liked by cattle except when it is very young. In time of famine, however, it gives some relief as a fodder, as it is a very hardy grass and resists drought more than many other ordinary grasses.

Sometimes its growth is so dense that the *desi* plough cannot enter the land, and no cultivation is possible. Examples of such lands are to be found in the *hithar* tracts of Chunian and Kasur and in the Ferozepur district. *Kussa* grass is held sacred by the Hindus.

Eradication.—The best method of cleaning lands infested with *dabh* is to plough them with inverting ploughs as deep as possible and to take out the underground stems thus brought up. This treatment should be continued until the land is quite clean of this weed.

Another perennial grass with extensive creeping roots is also known as *dabh* or *kussa* grass (*Imperata drundinacea*). It is widely dispersed in hills and plains, especially in clayey soils where free water is near the surface. Methods of eradication are similar to those in case of *Eragrostis cynosuroides.*

4. *Dila* or *motha* (*Cyperus rotunders Linn*).—Perennial.

Natural Order—*Cyperaceæ*.

Dila, though a perennial plant, grows only in summer. It is generally found in sugarcane, maize and cotton fields which are watered in the hot months. It has got under ground black tubers from which shoots come up the following year. It also propagates from seed. It is a very quick growing plant, and sprouts even one day after it is cut with a *khurpa.* It is considered to be a poor fodder, but its value is appreciated in May and June, when other grasses are scarce and people frequently bring it from cane fields, which are watered in those months. It is chopped and mixed with *thusa*. After the rains begin and other grasses come up, *dila* gets out of favour.

Eradication.—Sugarcane fields should not be followed by a *kharif* crop next year on lands where *dila* is very troublesome. Sugarcane should be followed (as is generally done) by wheat, for which land should receive cultivation in May and June, so that the tubers of *dila* may be killed. This weed is not yet so serious in the canal colonies as in the cane growing submontane Districts.

5. *Itsit* (*Boerhaavia diffusa*) and (*Trianthima pentandra*).—These two plants are known as *itsit* in Punjabi. *Itsit* is a common weed in the rains, especially in manured land and on waste lands, where dung cakes are made. It is cut or browsed on by animals, before seed formation. Old roots after deep ploughing should be brought out and burnt.

6. *Tandla* (*Digera arvensis*) is a common *kharif* weed in the Punjab plains. It is used as a pot-herb by the poor, and is also used as fodder. It is an annual plant, and is not hard to eradicate.

7. *Jangli Jut* (*Corchorus tridens Linn*).—(Annual).

Family—*Tiliaceæ.*

It is a weed of the *kharif* crops and propagates from seed. The best method to control is to remove the plant before flowering. In case of heavy infestation the land should be ploughed and left fallow for some time.

8. *Hazardana dodhak*—(*Euphorbia pilulifera Linn*).

Dodhak—(*Euphorbia heliescopia Linn*).

Kangi or *Richni*—(*Euphorbia dracunculoides*).

Dudhi—(*Euphorbia thymifolia Burm*).

Lal Dudhi—(*Euphorbia prostrata Ait*).

Family—*Euphorbiaceæ.*

These plants contain milky juice and produce numerous seeds from August to September, which are easily dispersed by wind and water. They give rise to fresh plants in March-April. In order to control, the plant should be persistently cut down before flowering takes place. *Lal Dudhi* is a very troublesome weed of grass lawns in the canal irrigated areas. After cutting down the grass and allowing the ground to dry well, 5 per cent. solution of common salt can be spread with advantage on a dry day between 10 a.m. and 2 p.m. The red weed will be found to wither up in a few hours after the application of salt solution, while grass will be found unharmed. Irrigation may be applied to land after 8 to 10 days. Care should be taken that the solution of the right strength is used and there is no dew on the ground when the solution is spread.

9. *Khumb* (*Orabanche cernua Orobanche nicotianae Wight*).—(Annual).

Family—*Orobanchaceæ*.

This is a flowering parasite and lives on the host by attaching itself to its roots by suckers and absorbs food. There are two types of this weed found in the Punjab—*Orobanche cernua* on *sarson* and *Orobanche nicotianae* found on tobacco and brinjals. In Hazro (Campbellpur district) it causes serious damage to tobacco crop. The plant propagates from seed which grows only when in close proximity of a host plant, to which it attaches itself at once. It usually appears above ground in April and flowers in May and produces abundant minute seeds which are scattered by wind all over the field. Sometimes the parasite grows vigorously, and the damage is so serious, when the crop is poor, that the whole of it withers away within a few days. The most effective remedy is to cut off the plants as soon as they appear and thus prevent the formation of seed, and infected fields should be heavily manured so as to enable the tobacco plants to be strong and resist the attack of the parasite. Moreover, tobacco should not be grown in the same fields year after year, and the nursery should be grown in beds free of seed of *orobanche*.

10. *Dhaulphuli* (*Striga densiflora Benth*).
(*Striga lutea, Laur*).
(*Striga Euphrasioides Benth*).

Family.—*Scrophulariaceæ.*

These plants are root parasites on sugarcane and *jowar* in most parts of the Punjab and cause considerable damage to them. Striga has been reported also on *bajra*, maize and Sudan grass. The roots are closely connected with those of host plants and by means of these suck up food from them. It propagates from the seed thus left in the field, which germinates, in the presence of the host plant only, during July-August. To control it the parasite should be cut down as soon as it appears, to prevent seed formation. Subsequently new shoots should be removed. Badly infected fields should be left fallow for sometime and then sown with leguminous fodder instead of *jowar* or sugarcane.

11. *Bhakhra* (*Tribulus terrestris*).—(Annual).

Family—*Zygophylaceæ.*

It is found growing in almost all *kharif* crops and on dry waste places. On account of its hardy nature it can spread very quickly over larger areas. It produces flowers and fruits from June to September. The seeds are protected by the hard covering of fruits which keep them viable for a long time. The spines help in the dispersal of seed by getting attached to feet of cattle and human dress. In order to control, it should be cut at the ground level frequently before flowering.

12. Many other *kharif* weeds, such as *chulai* (*Amarantus blitum Linn* and *Amarantus viridis Linn*), *daryai buti* (*Cleome stricta Wild*), *bauphali* (*Corchorus antichorus Rou.*—Jem's Mellow), *oont katara* (*Heliotropium supinum*), *lunak* (*Portulaca oleracea*), *jangli palak.* (*Rumex acutus*), and annual grasses such as *jangli sawank* (*Panicum colonum*), *madhana* (*Eleusine egyptiacum*), *phulan, lanb ghas* (*Eragrostis sp.*), *bunin* and *bhurat* (*Cenchrus catharticus*) or (*Cenchrus echinatus*), etc., grow among crops and on water channels and bare lands.

Most of these weeds and grasses can be easily eradicated by cutting down the plants before flowering. Some of the grasses, such as *sawank* and *madhana* are believed to be good fodder grasses, while others have little nutritive value. All these grasses can be eradicated from crops by interculture and from fallow fields by cultivation. Once they are uprooted most of them do not sprout again. They should not, however, be allowed to mature seeds. The grain of wild *Sawanak* (*Panicum colonum*) is eaten by Hindus on fast days.

Rabi weeds.

1. *Piazi* or *bhughat* (*Asphodelus fistulosus*).—Annual.

Natural Order—*Liliaceæ*.

A very common weed in the *rabi* season, but ordinarily of no use as a fodder or a pot-herb. Seed germinates in October and November, and flowers are formed in March. Seed ripens along with wheat.

Eradication.—In canal irrigated tracts, fields watered and prepared for wheat should be left for about a week. *Piazi* seeds will during this time germinate. The young seedlings will be destroyed when the fields are ploughed for sowing wheat. This process is called *dab*. *Dab* is not possible for very late sowings. The bar harrow if used on young wheat also eradicates to some extent the young seedlings of *piazi*. In all other cases plants should be cut below the crown of leaves before the seed is ripe. Use always seed free from *piazi* seed.

2. *Bathu* (*Chenopodium album*).—Annual.

Natural Order—*Salsolaceæ*.

Bathu is one of the most troublesome weeds in wheat and winter garden crops. It is used as a pot-herb by the poor and also as a fodder. Seed of *bathu* ripens earlier than wheat.

Eradication.—It ripens its seed much earlier than is generally realised. The whole plants and spikes are quite green when seed is quite ripe. If the plants are fed to cattle at this stage, some seed is sure to find its way to the fields through the manure. Such plants should not be fed to cattle, and, if done, the refuse should not be taken to the manure heap, especially if it is soon to be carted to the fields. Such plants should not also be allowed to remain in the field after being cut. *Bathu* plants sprout again if cut above ground. They should, therefore, always be cut with a *khurpa* a little below the surface of the ground.

Bathu seed germinates slowly. Therefore *dab* is not so useful for it as for *piazi* (*Asphodelus fistulosus*). Very young *bathu* plants can be eradicated to some extent if a bar harrow or a peg tooth harrow is worked in the field.

Seeds of all the *rabi* field crops (wheat, oats, gram, barley, etc.) should be passed through a winnower should they contain weed seeds. Seeds of many weeds such as *bathu*, *piazi*, *lehli* (bind weed) and *dokan* (*Lathyrus aphaca*), etc., will mostly be removed in this way. They can be partly removed also by women using the *chhaj* and separating by hand.

3. *Pohli* (*Carthamus oxyacantha*).—Annual.

Natural Order—*Compositæ*.

The plant has no spines when young. It is used as a fodder, and sometimes as a pot-herb by the poor at this stage. The seed is roasted and eaten by poor people. The seed is ripe in May. An edible oil is also extracted from the seeds, which is said to be used for adulterating *ghee*.

Eradication.—It is a very bad weed if once established. Some lands in the Ferozepur District are so much infested with it that *rabi* crops cannot be harvested conveniently if sown there. Early action should be taken if this weed seems to be increasing year by year. Seed ripens in May. All the plants should, therefore, be cut down along with crop if not taken out while young. Ordinary reaping by *darantis* often mean leaving all *pohli* uncut. A reaper can be used with advantage for this purpose. All people affected should take up concerted action, otherwise seed will be blown from neighbouring fields to those from which plants have been removed. In recent years considerable success has been achieved by organizing regular campaigns for the eradication of this weed by the Agricultural Department.

4. *Leh* (*Cirsium arvense*).—Annual.

Natural Order—*Compositæ.*

It is commonly found in *bet* lands and also in some other places. It is of no use to man or cattle. Seeds have got hairy appendages by which they can be easily blown away by wind. Plants should be cut or ploughed up with an iron plough before the seed is ripe. The *desi* plough is not useful for this purpose, as the roots of this plant are very deep and cannot be broken with it.

5. *Lehli*, *bakar bel* or *verhi* (*Convolvulus arvensis*).—Perennial.

Natural Order—*Convolvulaceæ.*

Lehli is a common weed in the Punjab. It is perennial and deep rooting with extensive creeping cord-like fleshy root-stocks. These root-stocks throw up slender stems, which twist around the stems of crops, using them as supports, and partly choking them. It grows throughout the year, though growth is much more active in winter. *Lehli* weed is a good fodder for cattle, sheep and goats.

Its propagation is both by seed and running root-stocks, every portion of which will give rise to a new plant if broken by the plough in moist soil. Though growing throughout the year, its seed ripens in April and May.

It is exceedingly hard to eradicate owing to the vitality of the fleshy root-stocks. Care should be taken that seeds of winter crops do not contain *lehli* seed. The plants of *lehli* should be cut with *khurpa* or *dranti* persistently during its growth. In fallow fields the persistent use of *panjdanta* with broad *khurpa* like scrapers has proved very useful in eradicating *lehli*. Second crop of this weed should not be allowed to manufacture sufficient food to nourish the underground root-stocks, after the first one has been destroyed. This is one of our worst Punjab weeds.

6. *Maina* (*Medicago denticulata*).—Annual.

Natural Order—*Leguminosæ.*

Maina is an annual weed growing in winter. It is a leguminous plant and is used as a fodder for cattle. It is said to cause colic in horses. Sometimes its seed is sown in *toria* and cotton fields in October. After the main crop is removed *maina* is irrigated. *Maina* should be fed before its stems, which are wiry, become too hard and the pods are ripe.

Poor people use it as a pot-herb. *Maina* becomes a serious weed in the submontane tracts only in those years when it rains too much in winter. *Maina* is found generally on heavy and loam soils. It is not a common weed on light lands.

Eradication.—Cut it and use it as a fodder before its seed is ripe. Being a leguminous plant it enriches the soil if ploughed in with an iron plough on fallow lands. Winter crop seeds should not contain *maina* seed.

7. *Maini* (*Trigonella polyserrata*).—Annual.

Natural Order—*Leguminosæ*.

Maini has a darker colour than *maina*. Its pods are straight, whilst those of *maina* are curled. The latter is more spreading in habit than *maini*, the leaves of which are dented and are sometimes used as a pot-herb. *Maini* grows on light lands where *maina* is not so common. It is said to cause tympanitis occasionally when fed to cattle. Methods of eradication are similar to those in case of *maina*.

8. *Takla* or cow cockle (*Saponaria vaccaria*).—Annual.

Natural Order—*Caryophyllaceæ*.

It is an annual weed with pink flowers frequently met with in wheat fields. Its seed is round and full black in colour about 1/12th inch in diameter. It not only robs the plant food and moisture, but its seed forms an objectionable impurity in commercial wheat.

Eradication.—Use pure seed and pull out all the plants of *takla* before its seed is ripe.

9. *Rari* or *rewari* (*Vicia sativa*).—Annual.

Natural Order—*Leguminosæ*.

It is an annual leguminous winter weed and is used as a fodder.

Eradication.—Use pure seed and cut the weed plants before its seed is ripe and use as fodder.

10. *Akasbel* or *Dodder* (*Cuscuta reflexa Roxb*).—Perennial Family—*Convolvulaceæ*.

It is commonly found growing on *ber* (*Jujube*) and other trees and hedges of *duranta* and *sanotha*. It propagates from seed as well as vegetatively from the stem. The seed germinates in the soil, producing a colourless, thread-like stalk which on coming in contact with a suitable host becomes attached to it, sends sucking roots into its tissue, and severs its connection with the soil. Broken pieces of the parasite on coming in contact with the host also grow on the plants. The growth of the host plant is first checked but it is ultimately killed if the parasite is allowed to grow. All infected branches should be cut and burnt to prevent further infection by seeds or pieces of stem. In a severe attack the host plant should be cut near the ground level. This unsightly parasite is spreading rather seriously in the Punjab.

11. Many other annual weeds are met with in winter, such as *shahtara* (*Fumaria parviflora*), *kurund* (*Chenopodium murale*), *dhabbar* or *chandni* (*Anagallis arvensis*), *farid buti* (*Farsetia Edgeworthii*), *kasni* or chicory (*Chichorium Intyvus*), etc., excepting Chicery which is a very serious weed in berseem. Generally these weeds are not so troublesome as those already mentioned and can be kept in check if they are not allowed to ripen the seed. The best method to deal with chicory is to sow pure Berseem seed after cleaning it thoroughly. Chicory seed being lighter than the Berseem, floats on the water when put in it (see Chapter on Fodders) and can thus be easily removed.

References.

(1) Punjab weeds and their Control by Jai Chand Luthra (1938).

(2) Dept. of Agric., Punjab, leaflet No. 111.

PART II.—CROPS

CHAPTER XI

FOODGRAINS—CEREALS

WHEAT

Natural Order—*Graminanceae*, Tribe—*Hordeae.*

Botanical Name—*Triticum Sativum.*

Vernacular name—*Kanak.*

Wheat is the most important crop in the Province, both as regards area and value. It constitutes about half of the food consumed by *Punjabis* though in the south-east the proportion of wheat in the diet is less. It is higher than 50 per cent in Districts like Amritsar, Lahore, Gujranwala, Lyallpur. The *Zemindar* relies largely on his surplus wheat to pay land revenue and water-rate, amounting to about 4 crores for the *rabi* season. Taking production at 3.75 million tons and value Rs. 5 per *maund* the Punjab crop is worth Rs. 52 crores aud at Rs. 10 it is worth Rs. 104 crores.

The Punjab has 28 percent of the wheat area of India.

Area.

The ten million acres grown consist of 55 per cent. irrigated wheat and 45 per cent. *barani* (rain grown). The irrigated area is gradually increasing, whereas, the *barani* varies according to rainfall, so that sometimes the total area may be 10.5 million acres or as low as 9.0 million. Actual area for the quinquennium ending 1943-44 was 9,982,000 acres. The Punjab with 28 per cent. and U.P. with 23 per cent. constitute between them 51 per cent. of the total wheat area of India, but the surplus for export in the Punjab is often a million tons, whereas the U. P. is often a deficit Province. As regards world production India comes third after U.S.S.R. and U.S.A. with Canada being the fourth.

Yield. Comparative yields in various Countries* are given below:—

Country.	*Yield in maunds per acre.*
Denmark	30¾
England	24
Germany	22½
Egypt	19
U.S.A.	10
British India	7¾
Punjab	10

On irrigated land in the Punjab the yield is 11 to 13 *maunds* and 5 to 7 *maunds* on unirrigated. Assured supply of water and newer land account for the greater yield in irrigated areas. Even Punjab yields are low compared to other countries (see statement above). At Lyallpur Agricultural Station a yield of 56½ *maunds* per acre was obtained in 1938-39 on an area of $\frac{1}{27}$th acre and this shows the enormous scope for improvement. The new varieties such as 8A, C 518 and C 591 introduced by the Agricultural Department and which now occupy 75 percent of the wheat area, give an increased yield of 1 to 3 *maunds* per acre.

Total production and utilization. The average total production of Punjab wheat is 3.75 million tons as compared to 9¼ million tons for India.

The statement below gives usual disposal.

	Tons.
Large power roller mills	275,000
Chakkis driven by electricity or oil engines	900,000
Gharats or water driven *chakkis*	50,000
Hand *chakkis* or *kharas*	1,250,000
Total	2,475,000
Required for seed	205,000
Stock feeding	30,000
Total	2,710,000

*U. S. A., Agric. Statistics.

This leaves about one million tons available for export. The export margin is affected by the yield and price of alternative foods such as *bajra*, maize, pulses, etc. Increase of population in the last 20 years has decreased the margin for export. During 1942-43 the exportable surplus exceeded 12 lakh tons.

Large mills and *chakkis* driven by oil engines or electricity function in towns and *gharats*, *kharases* and *chakkis* are used mostly in rural areas and turn out *ata* (wholemeal flour). The larger mills turn out *maida* (flour), *suji* (coarse semolina), *rawa* (fine Semolina) and *ata* and bran. A common percentage before 1940 was *maida* 27 perc ent, *suji* and *rawa* 18 per cent, *ata* 40 per cent, and *bran* 15 per cent. From wholemeal *ata*, the coarsest *bran* only say 1 to 3 per cent. is removed by hand sieve before making *chapatis*—(unleavened bread). Wholemeal *ata* is more nutritious than the mill product.* It is also believed to contain more vitamins. It is believed, oil driven *chakkis* by causing heating result in some loss of Vitamins B and in oxidation of calcium and phosphorous salts. Careful scientific work is still required to prove this theory, but it may be of interest to note that *kharas ata* fetches from 5 to 8 annas a *maund* higher than other *ata*.

Wheat products are also used for *dabal roti* (bread), *sewyan*, *halwa*, and sweetmeats of various kinds. Some *maida* is used also in soap manufacture and wheat starch is much prized for sizing cotton cloth.

Classification.

There are three species of wheat in the Punjab, namely *T. Durum* (*Wadanak* or Macaroni wheats) *T. Compactum* (Dwarf wheat) and the common *T. Vulgare*. Howard's classification of Punjab wheats in 1911 gave 25 varieties and since then the Agricultural Department have isolated a total of over 40.

*Punjab Wheat Marketing Report, 1940.

"Wadanak wheats."

Three varieties have been isolated; all have bearded ears and tall strong straw. They require good land and copious water supply and are mostly grown under well-irrigation or in sub-montane districts. No. 1 is grown largely in Sialkot and Gujranwala districts. The grains are long and unsuitable for modern mills, but the flour is prized for macaroni, semolina, and sweetmeats, and fetches a premium in consequence, 2 to 4 annas a *maund*. These wheats do not lodge easily. *Wadanak* wheats occupy a strictly limited area.

Compactum wheats.

Four types have been isolated of which one is half-bearded, the other three beardless. The heads are short and dense and the straw short and stiff. The grain is round and small and for this reason unsuitable for modern mills or export. They were commonly grown in south-western districts as they ripen well in hotter climates, but their cultivation has practically ceased.

Vulgare wheats.

The bulk of the Punjab wheat come under this class. Originally 18 types were isolated by Howard but the number has since increased to 33. The grains are of medium size, white, amber or red in colour and in structure the endosperm may range from soft to hard.

The hard and semi-hard wheats known as *sharbati* are most popular and are spreading all over the province—particularly in the canal colonies where C 591 is now extensively grown. Red wheat, though originally grown in nearly all districts and predominant in some, is loosing ground. On unirrigated land and many well irrigated areas types 13, 14 and 15—the former with red chaff and the latter two with white—are most important. Red wheats are still important in the north-west in Attock, Rawalpindi and Jhelum and in the south-east in Hissar, Rohtak and Gurgaon, but even here, the change has definitely set in. Red wheats sometime fetch a small premium as the *ata* is believed to mix better with gram flour.

The Botanical surveys showed that local wheat was everywhere a mixture of types—*viz.*, 11, 13, 14, 16, 17, 24, 25 as classified by Howard and others since isolated. Economic improvement started with the distribution of No. 11 (*Lal kasaruali*) bearded white wheat with smooth red chaff. Punjab 17 a beardless white hard wheat also found favour with some cultivators on account of its *chapati* making qualities. In *barani* areas type 14—a bearded soft red wheat had some success. But type 11 enjoyed the greatest popularity from 1913 to 1925. Thereafter type 8A, isolated subsequently to Howard's classification, rapidly replaced it as is shown below:—

Improved types.

Area under improved wheat in the Punjab
(Thousands of acres).

	8A	*No. 11*	*Others*	*Total*
1925-26	834	625	10	1,469
1928-29	1,752	252	93	2,100
1933-34	2,805	41	89	2,935
1936-37	3,300	21	703	4,024

In 1932, 9D a fully-bearded type with white awns, white felted chaff and amber grains, was found particularly suited for *barani* tracts and late sowings in irrigated tracts. Its susceptibility to rust in humid areas has restricted its expansion in Rawalpindi and Gurdaspur. A type known as C 217 is finding favour in Rawalpindi.

In 1934, two more hard white wheats C 518 and C 591—both hybrids—were distributed for general cultivation. Cross 518 is reputed to yield 3 *maunds* more than 8A. It is a fully-bearded, short-awned amber-grained wheat with short stiff straw. It is especially suited for rich irrigated lands and has yielded occasionally over 50 *maunds* per acre. Cross 591 is also fully bearded with slightly greyish awns and tall straw, though fairly stiff. The grain is the most attractive of all Indian wheats and excellent for *chapattis*. It fetches a premium of 2 to 4 annas a *maund* over the best wheat in the market and yields one *maund* more than 8A and beats even 9D under late sown conditions. It has made rapid strides.

Pusa wheats.

These have been frequently tried in the province, but they do not come up to C 518, though better than 8A, under humid conditions. One Pusa wheat 80-5 is popular in Simla and Kulu.

Soil.

Wheat is grown everywhere, except on very light unirrigated high land. A medium loam suits wheat best in the dry climate of the Punjab. In the western canal colonies wheat generally occupies 35 to 45 per cent. of the total area cropped. The highest yields are obtained on well lands of the central districts, as wells are on selected and well-manured soil. It is not a question of difference in nature of water supply.

Season.

Sowing takes place from mid-October to end of November but may continue through December and even as late as early January. Late-sown wheat yields less than early sown. Harvesting starts from 10th April to 20th April, except in the south-east, where it is 10 days earlier. Wheat is generally cut by end of April.

Fallows and rotations.

Wheat likes to come after fallow—better a long than a short fallow. On irrigated lands the long period crops, cotton and sugarcane, are generally followed by wheat. Early summer fodders also sometimes precede wheat and in most districts there are areas where wheat follows wheat. Maize, which is manured, is sometimes followed by wheat, but it is not a good rotation from point of view of yield. In *barani* land wheat follows a previous winter crop or a summer crop of the previous year.

Mixtures.

Early winter fodder such as *sarson* is sometimes mixed with wheat but the bulk of the crop on irrigated areas is grown pure. In *barani* areas wheat and gram are generally sown mixed (see Chap. VII). Most wheat contains one or two per cent. of barley, and 2 per cent barley and $1\frac{1}{2}$ per cent dirt is the basis of the Standard Export Karachi Contract as against local Karachi Contract of 5 percent barley and 3 per cent dirt.

Barley mixed in wheat.

In many parts of the province there is often admixture of barley in the wheat fields. For this there seems no justification, for such an admixture can have no value for an insurance against the vagaries of season and the buyers in such cases pay for the barley at only half of the wheat price. This impurity certainly entails loss to the grower. In the canal colonies especially the Lower Chenab and Lower Bari Doab canal colonies, the purity of wheat has been greatly improved as a result of the work of the Agricultural Department, which distributes yearly several thousand tons of pure seed. To ensure pure wheat in the colony markets, it is desirable that the prices should be calculated on the assumption that the wheat will be pure. At present the rates are generally quoted in the markets for wheat containing 2 per cent barley; and though it is true that a bonus is given for purity above this basis, such a bonus will seldom reach a small grower. If market rates were calculated on pure wheat basis, with mutual terms of contract, there would certainly be further improvement in the freedom of wheats from barley.

Preliminary cultivation.

The importance of cultivation of the soil before sowing is generally well realised—as the prime factor in securing a good yield. In *barani* tracts the soil may be ploughed with the *desi* plough as many as 20 times and in general 8 to 10 ploughings is the custom. Even on irrigated land 5 to 6 ploughings are given, of which one or two may be with a furrow-turning plough. Clods are broken by taking the *sohaga* over the land after ploughing. If manure is available it may be given, but generally speaking wheat is not directly manured.

Seed rate.

The usual rate is 24 seers but in Karnal and Rohtak as much as 40 seers is used. In some colony lands as little as 16 seers is sometimes used. Late sown wheat requires a higher seed-rate as is the case with cotton and many other crops. The reason for the high seed-rate in Karnal and Rohtak is not known.

On *barani* lands, the seed-rate is sometimes higher and sometimes less than on irrigated land. Low seed-rate is probably used in some cases due to deficient moisture to support a thick crop. Again some wheats "tiller" well and that means a lower seed-rate. It may be of interest to note that a head of wheat generally contains 19 to 20 spikelets with a minimum of 3 and sometimes 4 or 5 grains. Each grain that germinates and persists gives an average of say 4 shoots, so that the number of grains from one seed may be 240. If every grain sown were fully successful, a seed-rate of 20 seers ought to give 120 *maunds.*

Sowing.

Sowing methods have been described in Chapter V. Recently on irrigated land a new method has been evolved. When water is short the last few acres in a holding may not have been sown till December. If the seed is sown on dry land and water applied afterwards the cultivator saves 6 or 7 days of waiting for the land to be in *vattar* before sowing. Germination is earlier and better by this method and it is believed better yields also result.

Harrowing.

On irrigated lands the soil is usually run over with the *sohaga* after sowing. This leaves the surface smooth and ideal for evaporation of water. Such a soil can lose more water by evaporation than a free water surface. By running a bar harrow, introduced by the Agricultural Department, over the soil, a light mulch is left which protects the soil from excessive loss of moisture and enables subsequent harrowings to be more effective.

After cultivation.

Usually little is done. In all cases if rain falls shortly after sowing a light harrowing would be very beneficial, even after germination has occurred. In Europe it is a common practice to harrow the young crop and in dry land to pass the roller over it also. There is no doubt harrowing checks weed seedlings such as *piazi* (wild onion), *rewari* and *bathu*. It checks white-ant damage also and should help to delay the first watering after sowing. In some districts wheat is hand-hoed usually once and sometimes twice and this is a sound practice, but expensive compared to harrowing.

Irrigation.

A large number of experiments in India and elsewhere have shown that under best conditions a yield of 40 maunds can be obtained with 12" of irrigation water on a field scale. This means three irrigations after sowing and one before (*rauni*). Allowing for evaporation it appears, therefore, that 10 or 11 inches of water is transpired through the plants.

To achieve such a high "duty" the losses from the soil by evaporation must be kept as low as possible. Other factors are good cultivation and if possible manuring. Experiments in Pusa by Leather and in the U.S.A. have shown that a pound of dry matter is produced with less water in manured and well-prepared soil than when the reverse is the case. General experience also shows that the same amount of water in poor soil may give less than half the crop in a good soil. As water is the limiting factor in canal areas, it would be well if we could think of yields per unit of water, rather than of land. This might open up new vistas both for the farmer and the irrigation engineer. If water is given in small quantities at a time as in well-irrigation there is a tendency for excessive evaporation. In comparing "duties" for well irrigation and canals, it must be remembered that canal "duties" are calculated on water measured at heads of distributaries. Often the loss from Head to the field is considerable (See Chapter VIII).

The ordinary practice in Canal Colonies agrees fairly well with these figures. Usually one irrigation is given in summer for soil preparation (called *wahn*). If rains are timely this is omitted. Most of this is lost by evaporation before the *rauni* or pre-sowing water. After sowing 2 or 3 irrigations are given—usually of 3 inches or less each, the *rauni* watering being generally 4 inches, making a total if we omit "*wahn*" of 10 or 13 inches. At Lyallpur good crops of 25 to 30 maunds according to the season, have been repeatedly obtained with two waterings after sowing. This makes a total quantity including rainfall of 12 inches.

Farmers know excellent crops can be grown with two waterings after sowing, if all conditions are favourable and the waterings can be given at the proper time. A delay of a week in the March irrigation may often cause very serious loss in yield. Three irrigations after sowing are, therefore, generally necessary. It will be noticed that in case only two are given there is an interval of 3 months between *rauni* and *kor*. This is impossible in salty land or in soil of poor condition or for early sown wheat, without a serious drop in yield. Early sown wheat should receive *kor* irrigation in December. The "duty" in the Punjab is up to the standard of the best American experiments and higher than is obtained in general practice anywhere else in the world.

Necessity for investigation.

The best irrigation practice for salt or *kallar* soils, poor soils and good soils still needs a good deal of investigation. Work on this and other allied problems is already in progress in the Research Station at Lyallpur.

Pests: white ant.

These attack the young plants in light dry soils and often do serious damage. Harrowing helps but irrigation (*kor*) is the only certain cure.

Rust.

This is the second most serious pest of wheat. Three kinds of rust are prevalent *viz.* (*Puccinia graminis*) black rust, (*Puccinia glumarum*) yellow rust and (*Puccinia triticina*) orange rust. Yellow rust is most common. The attack may occur in December or as late as February or March. In some years rust spreads rapidly. It is undoubtedly the biggest factor in affecting yields, but the December rust is more serious than late rust as latter generally only affects late sown crops. Rust may affect the yield up to 20 per cent. Some of the local varieties are partly immune, but so far we have not evolved a first class wheat which is completely immune—that remains to be done for the future.

Smut.

Loose smut of wheat (*Ustilago Tritici*) commonly known as *kangiari* can be very destructive, even 10 per cent in some fields, but for the province as a whole does not exceed 1 per cent. The disease is transmitted by affected seed which cannot be distinguished at sowing time. The treatment is simple, *viz.*, soaking in water for 4 hours and then exposure in the sun for four hours on a sunny day. The best precaution is to use seed from a healthy and high yielding field.

Frost.

Only late frost, say in early February, can do any real damage. Quite severe ground frosts in December and early January have little or no effect.

Hot winds.

If the weather at the end of March and first half of April is hot and windy shrivelling of the grain takes place and yields and quality are affected. Mild damp weather before harvest which is rare may cause some increase in rust, but generally results in well-filled bold grains.

Storms and hail.

Heavy wind after watering often causes lodging and shrivelled grain. Rats also sometimes damage lodged wheat. Hail is also common in end of March and early April. It is local in its attacks and generally in strips of a couple of miles wide. In 1937 about a lakh of acres were almost completely destroyed by hail or seriously damaged in Multan and Montgomery Districts. One Chak on B.C.G.A. Farm in Khanewal has had its crop destroyed 3 times in 22 years. Rain at flowering time, *i.e.*, end of February or early March may cause poor fertilization of flowers resulting in many spikelets having only 2 grains instead of 3 or more, and the lowest spikelets may be empty.

Harvesting.

This begins about mid-April and as the wheat ripens rapidly and sheds when ripe the harvesting should be as quick as possible. Some beardless wheats shed readily, besides being more liable to bird attack—particularly by migratory starlings. If the area is small the farmer cuts the wheat himself, but in the canal colonies where more area is grown he has to rely largely on hired labour. Usually local labour is insufficient and special labour comes in for the harvest from the south-east and from dry tracts.

Wheat is cut by hand, very low by means of a small saw-toothed sickle (*dranti*). After cutting it is either stacked loose in stacks known as *mandlis* or tied into bundles or sheaves, usually as much as a man can carry and then stacked to a height of 6 or 7 feet. Five men usually suffice to cut and stack au acre per day. They are usually paid in kind—one bundle out of 20 and each bundle weighs a *maund*. The cost comes to *R*s. 6-12.* In south-east Punjab a bundle or sheaf is only 4 or 5 *seers*. Sometimes the work is contracted out at Rs. 5 per acre based on pre-war figures.

Scythe.

This has replaced the sickle in Europe, as a man with it can cut up to an acre a day. In the Punjab the cutting has to be done in very warm weather and in trials at Lyallpur it was hoped at least half an acre a day could be cut. The straw, however, is slippery, the men dislike the upstanding position and a neat job could not be achieved. Further it is impossible with a scythe to cut as close to the ground as with a sickle. The experiment though persisted in for two or three years was abandoned.

Reaping machines.

Reapers drawn by cattle have been tried since 1909. They are only suitable for irrigated areas where fields are at least one acre in size. The Hornsby No. 10 with floating bar suitable for going and cutting over irrigation ridges has given most satisfaction. Their use spread during 1916 to 1920 but only 58 machines were sold from 1917-18 to 1934-35. Their use is confined now to large holdings and some big estates. The draft of the reaper is heavy, 240 lbs. and bullocks have to walk a bit faster than during ploughing. In consequence two pairs at least must be used per day in turn. They cut 8 acres a day though 6 is more common. Cost of reaping by reaper after allowing for depreciation, and interest is Rs. ~~3-12 per~~

*This is based on pre-war figures.

acre.* The high price of reapers about Rs. 400* militates against their success. If tractors come into more general use then there would be more scope for reapers. Two men generally work a reaper and six men collect and tie the sheaves. Self delivery and self-binding reapers have also been tried.

The machines are complicated and require two or three pairs of bullocks. Their use is only feasible with tractors.

Threshing.

This is carried out in most places by bullocks dragging a sort of hurdle known as *phalla* over the wheat spread on a hard earth which is sometimes carefully prepared beforehand. When a *phalla* is not used the operation is slow, so except on very small holdings it is customary to use *phalla*.

In the canal colonies the threshing floor is selected in the field and ploughed up again in the usual way when the rest of the field is being cultivated. In old districts, however, the village common (*shamlat*) is generally used. Such sites serve as recreation grounds and are not commonly cultivated. Generally only a little cleaning suffices to prepare a threshing floor, though some water the ground to make it compact and avoid dust and earth in the grain. It is generally hot and dry during the threshing season and this is ideal. Occasionally, however, rain and heavy wind do some damage. The straw on the threshing floor is repeatedly shaken up with a two or five pronged fork (*trangli*). The grain naturally falls to the bottom. On completion of threshing the threshed mixture is generally heaped in the middle to await winnowing.

Threshing is generally carried out by the farmer himself and his family. Three men and two pairs of bullocks can thresh the produce of an acre in a day. The cost works out at Rs. 4 per acre or 4 *annas* a *maund*.*

Winnowing.

Winnowing is commonly carried out by casual labour or menials, who also carry and stack the *bhusa*. They are paid in kind—generally 1/20th or say 2 *annas* if price of wheat is Rs. 2-8. Total

*These are based on pre-war figures.

cost of threshing and winnowing thus comes to 6 *annas* per *maund*.* The actual process of winnowing is done by (1) tossing the grain and chaff in the air by means of a pitchfork and (2) winnowing from a flat basket (*chhajj*) held high over the head in a tilting position. In most parts the person winnowing stands on the ground, in others, notably south eastern Punjab, he works from a platform.

Power Threshers.

As winds necessary for winnowing often fail and the threshed crop is sometimes liable to heavy losses from rain or storms the Agricultural Department has tried power threshers worked by steam or tractors. A dozen threshers were tried—none was found to be suitable. The problem of threshing in the Punjab is more difficult than in the Western Countries. The straw here becomes brittle and chokes up the riddles and this reduces output and increases costs. Other main defects were (1) greater breakage of grain than in the country method and (2) inability to produce *bhusa*. If threshers are to succeed it will probably be wiser to evolve threshers which make *bhusa*. *Bhusa* or bruised and crushed straw as obtained from bullock threshing is a very valuable feeding stuff, and it would be necessary to prepare it separately rather than use half broken straw. Again, broken grain increases weevil attack and affects keeping qualities. Except on one or two Military Farms no power threshers are in use in the Punjab.

Winnowers.

The evolution of a simple and cheap winnower which may be worked by hand or bullocks is one of our vital needs. Some experimental work has been done. A machine containing a fan and large riddles evolved by the Agricultural Engineer at Lyallpur has been constructed. A prize of Rs. 3,000 was recently awarded for the best winnowing machine within the reach of the ordinary farmer. Several interesting ideas evolved but even the best submitted requires much further work to be of practical importance.

*This is based on pre-war figures.

Wheat grain is stored by farmers in a variety of ways, *e.g.*, loose or in bags in rooms, in mud bins, either box-shaped or cylindrical (called *kothis* and *bharolas* respectively). The latter two methods are useful for small quantities for home consumption but not practical for large quantities intended for sale. Sometimes a corner of a room is selected and two mud walls erected at right angles forming a receptacle known as *bukhari*. This method is common in Central Punjab and especially among Jat Sikhs.

Storing of grain.

Circular or conical structures made of *sarkanda* or matting of plaited date-palm leaves, locally known as *pallis* are common in Dera Ghazi Khan and Muzaffargarh district. *Pallis* may be inside the house or in the open air close to the house. In south-eastern districts, particularly Rohtak and Karnal, tall cylindrical structures of closely-woven hemp cloth or gunny bags open at both ends are common. The lower end rests on a raised mud platform and the upper is tied by ropes to the roof. These are called *thekas* and are generally erected in the house. In some villages situated near the United Provinces, mud-plastered pits known as *khattis* with an opening at the top large enough for a man to pass through, are common. The capacity is generally about 300 *maunds*.

In the *mandis* or grain markets, the grain is stored generally in godowns or *kothas*, either in bulk or in bags. At Okara in Montgomery District, a few underground cellars have been constructed for storing grain.

Considerable losses are sustained due to rodents, insects and moisture with the present method of storage. It is estimated that the annual loss in storage from all these sources in the case of wheat comes to 3 per cent. of the total production. Taking the total production of wheat in the Punjab at 3¾ million tons, this means a loss of 112,500 tons and valuing the wheat at Rs. 5 per *maund* the annual loss is worth about 1½ *crores* of rupees. The Imperial Council of Agricultural Research estimates the storage losses to be about 3.3 million tons, *i.e.*,

Losses.

5 per cent. of all food grains in India. Mr. F. P. Coyne estimates the total loss for all food grains in India at 3 million tons.

Transport difficulties necessitating longer storage and the large importation of wheat during the war has made the problem of storage much more important than usual. The Government of India are, therefore, taking steps to reduce this heavy loss by constructing improved stores and encouraging private enterprise in that direction. In the "Principles of Cereal Storage by F.P. Coyne" published by the Department of Food, New Delhi, it is shown that temperature and humidity are the two important factors controlling storage losses. Extremes of temperature, above 100°F and below 55°F., large diurnal variations and low humidity are not favourable for insects. The moisture content of wheat grains, which is at equilibrium with air at 75°F and 75 per cent relative humidity is approximately 14 per cent and for any long term storage of grain its moisture content should not exceed this limit.

Wheat in the Punjab is harvested at the hottest and driest time of the year with a moisture content of 8-11 per cent. Below 8 per cent. moisture in grain there is little risk of insect attack. Insect life is likely to be destroyed as the grain lies in the hot sun during the threshing period. Such grain, if taken into the insect and moisture-proof store, would keep for years without any trouble. During monsoons, however, the relative humidity rises rapidly, the temperature goes down a little and the grain, if kept exposed to the atmosphere, will absorb some moisture from the moist air and will thus be more susceptible to insect attack. During winter from November onwards there is considerable fall in temperature and the grain is fairly safe from insect attack. It will thus be seen that in the Punjab the climatic conditions are not very favourable for the development of insects for the greater part of the year. The Punjab is, therefore, more suitable for the storing of wheat and other grains than the big consuming centres like Karachi, Bombay, and Calcutta, where the conditions are ideal for insect development.

For details regarding the construction of stores and control measures against insects and rodents Mr. F. P. Coyne's book may be seen.

Insect Damage.

The ordinary farmer recognises two types of insect damage of stored grain, *viz*., *khapra* and *susri* but in reality the damage is done by one insect in case of *khapra* and two insects in case of *susri*.

Khapra (Trogoderma granaria.)

This is more acclimatised to conditions of higher temperature and lower humidity than other grain insects. So it flourishes in the Punjab. The main damage is done by the larvæ, which is most active in the hot weather. Its presence is always evident from the cast skins, which result from the moulting of the larvae. The grain is attacked at any part but very frequently the embryo is selected and germination of grain may be affected long before any serious quantitative damage has occurred.

Its attack is confined to the top layer—rarely as deep as six inches in wheat stored in bulk. A high room or deep pit thus reduces damage.

Susri (Calendra Oryzae—Rhizopertha dominica.)

The latter of these two varieties of *susri* is smaller than the former. In both cases the eggs are laid on the grain, and then the aperture is sealed; so no attack is noticed. The larvæ spend their whole life inside the seed and emerge only after pupation. Holes in the grain are emergency holes and not entrance holes as is commonly believed. The actual damage is greater than it appears to be. The adults also feed on the grain. A large amount of floury matter is left mixed with the wheat.

Remedial measures.

The losses sustained through these insects can be considerably reduced, if wheat is taken from the field to a perfectly clean store. Care must be taken not to allow infection from old gunny bags or from an infected store. The store which is known to be infected must be thoroughly cleaned and can then be rendered safe by burning charcoal at the rate of 7 seers per 1,000 cubic feet and sealing the room for 48 hours. In this way a temperature of 150°F is reached. Infected gunny bags if turned inside out and left in the room can also be freed of insects in this way. "Seed Wheat" if taken straight from the field and put into mud *kothis* which are new, or free from weevil and sealed up with mud is safe from weevil. Larger quantities of seed can be partially protected by distributing naphthalene balls in muslin bags throughout and at the top layer at the rate of 8 lbs. per 100 *maunds.* Leaves of *neem* tree when obtainable are believed by farmers to be useful in the same way. Storage in or under *bhusa* of gram (*misa bhusa*) also tends to protect the wheat. Concrete underground godowns like those in use in Muzaffarnagar grain market in the U. P. are very suitable for storing wheat in bulk. They can be kept easily free of rats and are easy to clean. Damage by damp in such stores is negligible. Total damage is said to be not more than 1 per cent. in such stores as compared to 4.5 per cent. in *kacha khattis.* Such wheat also fetches a premium over wheat stored in *kacha khattis* of half an *anna* to two *annas* a *maund.* Though these concrete *khattis* cost Rs. 350 for capacity of 500 *maunds,* the cost of storage per month comes to 2·9 pies per *maund* as compared to 1·4 pies in case of *kothas.*

The Grain Elevator at Lyallpur referred to elsewhere in this chapter originally* used to charge 0·2 pies per *maund* per day for storage up to 15th July and thereafter 0·3 pies. This works to 6 and 9 pies per maund per month and was 3 to 4 times the cost of storage in *khattis.* The elevator is not used at present.

Storing of *Bhusa.*

Bhusa in this Province is stored either in small conical stacks thatched with straw, in low circular stacks roofed with mud, or in low-peaked heaps covered with mud and looking exactly like the English root "Clamp". These are known respectively as *kup, palla* and *dhar.* The first method is common in the wetter parts of the submontane tracts; the *palla* in the

* Wheat Marketing Report, Punjab—Page 172.

north-west districts; the *dhar* is suited only to the driest tracts. There is less wastage and damage from rain in the *kup* than in the others. The *dhar* is the worst in both respects, but it is easiest to make. A certain amount of skill is required for the putting up of a *palla* as the *bhusa* has to be tightly packed inside a barricade made of ordinary bedsteads set up on ends. The proportion between the yiled of straw and grain in the Punjab varies from 2 of straw to one of grain, to 1¼ of straw to one of grain. But in the case of *bhusa* the variation in the proportion of *bhusa* to grain is about 1.1 to 1.7 to 1. The yield of *bhusa* per unit of grain is less, because a part of the straw is lost in the process of threshing and winnowing. On the dry and unirrigated areas this proportion is low, whereas on the irrigated areas it is high. *Bhusa* is a valuable farm product for the cultivator, because it forms the basis of bulky food for cattle during almost the whole of the year mixed with such chaffed green fodder as is available. It will be readily understood that the breaking and bruising of the straw in threshing under bullocks and *palla* greatly increases its value as a cattle food. This is due to the great reduction effected in the expenditure of energy necessary to break it up by chewing. Thus in a rough experiment at Lyallpur, in which cattle fed on whole straw were compared with those fed on *bhusa*, both groups doing light work and receiving no other food, those fed on *bhusa* lost in weight on the average about 1 lb. per day whilst those fed on long straw lost weight at the rate of about 3 lbs. per day.

Recent researches in the Chemical Section of the Punjab Agricultural College, Lyallpur, have also shown that wheat-*bhusa* varies in its composition from year to year and place to place and is not a maintenance ration. The deficiency, however, can be made good by supplementing it with leguminous green fodder.

Wheat trade.

Imports of wheat and wheat-flour into the Punjab Trade Block are small, but the export trade is considerable, the average annual exports of wheat and wheat-flour for the four years' period ending 1936-37 being about 4 *lakh* tons. Nearly half of this was consigned to Karachi, wherefrom it was shipped as "Choice White Karachi". Another 28 per cent found its way to Calcutta and Bombay. Among the Provinces and States, the U. P. and Rajputana were the most important destinations. During the 20 years before 1939 when the second world war started the Punjab lost Hyderabad (Deccan), C. P. and Berar and Sindh as markets but gained Bihar, Orissa and Madras. During the war to date, the Punjab has virtually been the granary of India. In 1942, it supplied over 90 per cent of the total exported from all provinces and in 1943 exported a total of 12 *lakh* of tons of wheat and wheat products in addition to 4 *lakh* tons of other grains.

Future markets.

Owing to expansion of sugarcane cultivation in U. P. and Behar, the area under wheat has tended to decrease, and they promise to remain important markets for Punjab wheat. The importation of Australian wheat before the war was a serious problem. The cost of transport of Punjab wheat to Calcutta by rail before the war was over Re. 1 a *maund*—a very serious handicap as compared to sea transport from Australia.

Railway freight.

The Punjab being a land-locked Province, its surplus produce has to move long distances before it reaches ports for export or consumption centres elsewhere. The railway freight from Lyallpur to Calcutta was before the war Rs. 1-0-4 and to Bombay Re. 1-4-0 as compared to 7 *annas* per *maund* sea freight from Australia. Inland freight in Australia to port is only Re. 0-4-6 so that the total transport cost to Calcutta does not exceed Re. 0-12-0 per *maund*. This latter figure happens to be the freight from Lyallpur to Karachi also. From 1929 to 1939 the price of wheat at Lyallpur ranged between Rs. 1-8 and Rs. 3-8, so it will be realized that freight represents a very considerable percentage of cost at Calcutta or Bombay.

Freight for mill products.

Wheat sent from the Punjab to Calcutta gets a concession of Re. 0-3-5 in freight, whereas wheat-flour pays the full rates. This has put our flour-mill industry at a disadvantage in competition with Calcutta mills.

Exports.

This in the past was dealt with by a few firms of international repute such as Rallis, Louis Dreyfus, etc. Since 1928-29 the amount exported out of India has been inconsiderable, and the wheat firms have largely ceased to keep their own agencies and sub-agencies in the wheat surplus areas. Now the business is done largely through *pucca arhatyas* and "guarantee brokers". A deposit is generally taken from the "guarantee brokers" as security for fulfilment of contracts made on behalf of exporting firms. The "Karachi Pass" contract is often utilized for ready purchases. Wheat sold under this system is booked by the seller to the buyer at Karachi. He receives 90 per cent against railway receipt and the balance after deductions or in some cases additions made in Karachi for dirt, barley, weevilled grain, immature grain, etc. The standard export contract is 2 per cent barley and 1½ per cent dirt but the local Karachi contract is often based on 5 per cent barley and 3 per cent dirt. The existence of such local contract terms has tended in the past to greater adulteration. An enquiry conducted in respect of an important market showed that adulteration took place at various stages in the trade channel. An All India Standard Contract has now been drawn up as a result of repeated conferences and discussions with the Marketing Officers of the Government of India. Up to now Indian wheat has not been tenderable against the Future Contract in Liverpool—mainly owing to differences in quality. It is expected that this difficulty will be removed as improved varieties and standardisation of wheat are tending to bring Indian wheat up to the required standard.

Protection.

In 1931, an import duty of Rs. 2 and Rs. 2-8 per cent was levied respectively on wheat and wheat-flour from other countries, particularly Australia, which, as pointed out above, can land wheat in Calcutta at much less cost than the Punjab wheat. The duty was reduced to Rs. 1-8 in 1935 and to Re. 1 in 1936 and abolished in March 1937. Its abolition led to dumping and it was re-imposed from 7th December, 1938 at Rs. 1-8 per cwt. The duty was again reduced to

Re. 0-2-0 in September, 1941, and finally abolished in December, 1941, as price of wheat in the Punjab had risen owing to the war. There is little doubt that in post-war years this question will again come into prominence, if and when wheat prices fall to a serious extent.

Wheat elevator.

Wheat export from the Punjab is a parcel trade. The wheat is sent in gunny bags. In other countries notably Canada and the U.S.A., wheat is handled in bulk and stored in elevators prior to shipment. It is carried on the railways in bulk and shipped in bulk through elevators at the ports. This undoubtedly reduces handling charges but entails a large initial cost. An experimental elevator with 32 bins and cleaning machinery was erected at Lyallpur and started work in June, 1920. It was worked for 6 years and has since been idle. It had no real chance of success, without a complete change in transport methods generally and the erection of similar elevators at ports. It is doubtful in view of the decrease in exports, whether this reform will ever be practical in India.

Flour industry.

There are 22 roller flour mills in the Punjab and they grind about 275,000 tons of wheat per annum (see page 221). Flour mill *ata* is not wholemeal *ata* and before the war generally sold below the price of wheat, whereas *Chakki ata* used to fetch from Re. 0-2-0 to Re. 0-6-0 above wheat prices. The actual cost of milling in the Punjab before the present war was about Re. 0-4-6 per *maund*. Before the war *maida*, *suji* and *rawa* fetched generally from Re. 0-4-0 to 0-6-0 above wheat prices, but during the war a premium of upwards of two rupees per *maund* was easily obtainable. It will probably be necessary to standardize "extraction" and quality in the future to eliminate some of the pre-war abuses.

Quality requirements.

As wheat is used mainly for bread-making, the value depends on the amount of flour which can be extracted and the quality of loaf which can be baked from a given quantity of flour.

This is often referred to as "strength" of the wheat. There is now at Lyallpur a Model Milling and Baking Plant which is used for classifying wheats and carrying out milling tests. Indian wheats are generally of medium strength while Canadian wheats are in general hard and strong and Australian wheats soft and white. Only for biscuit-making and pastry is soft wheat preferred—though some mills mix soft and strong wheats as soft wheats give a whiter flour.

Selection and breeding work.

Improvement work has been in progress since 1907. The wheats were first separated and tested for yield against one another. Replacement of mixtures by high-yielding pure types was the first big line of advance. In deciding which type to put out yield was the main criterion and quality very secondary. Both No. 11 and No. 8A are not particularly high-quality wheats, but in yielding power and profit per acre they represented a very substantial gain to the grower. The next stage after exhausting selection possibilities, was breeding by crossing high quality wheats with high-yielding wheats. No. C 518 and C 591 were obtained by crossing. In order to hasten the work of breeding the seed obtained in Lyallpur in May was sent to Lahaul in the Kangra District and grown as a summer crop there. The crop matured in time to be brought to Lyallpur for winter sowing—so that we get two crops a year. Lately the summer crop has been raised in Murree Hills. The growing of two crops of wheat per annum has greatly increased the rapidity with which new types can be evolved and tested. A similar plan is possible for cotton, by sending seed to Madras but the Indian Central Cotton Committee were a bit doubtful, owing to risk of introducing new pests—a somewhat exaggerated danger.

The fixed or stable types secured by breeding are then tested for yields, rust resistance, tillering power, relative time of earing, size and weight of heads, shape, size and uniformity of grains, etc. Those showing promise are selected and given trials under field scale conditions. Milling, baking and *chapatti* tests are also carried out. When final selections are made, these are tested in Government farms and tested against standard varieties such as C 591. With application of modern statistical methods the reliability of results obtained by these experiments has been considerably increased.

The next step is large-scale testing with selected growers, who undertake to keep all the seed for sowing or sell it to the Department of Agriculture. As an instance of the quantity of wheat-seed sold by the Department it may be mentioned that in 1944, a total of 164,800 *maunds* was distributed sufficient to sow 275,000 acres.

Seed nucleus.

As most varieties of wheat suffer from loose smut and as natural crossing is apt to take place in the zemindar's fields a scheme is in operation whereby small quantities of absolutely pure seed free from smut are issued from Lyallpur every year (Risalewala Seed Farm) for further multiplication. Great care is taken in keeping up purity and health of seed. Hot water treatment and sunning and the roguing of crops are essential features of the scheme.

Cost of producing wheat.

The farmer is naturally concerned with the efficient production of crops. Without a knowledge of costs it is impossible to know to what extent efficiency can be introduced. Cost studies also show the profit or loss position. An inquiry into cost of production of crops was first started at Lyallpur (Risalewala) from 1927-28 to 1931-32:—The average figures are given below:—*

	Rs.	a.	p.
Manual Labour	5	4	0
Bullock Labour	15	0	1
Water-rates ..	5	4	0
Seed	2	5	3
Manure	0	13	8
Implements	4	2	5
Kamins	0	10	8
Harvesting	1	15	3
Winnowing	2	3	4
Total ..	37	10	8

*The Punjab Board of Economic Inquiry, Publication No. 33 by S. S. S. Kartar Singh, page 18.

The average yield was 19 *maunds* 3 *seers* 7 *chattaks* so the cost per *maund* comes to Rs. 1-3-8, after deducting Re. 0-14-4 as the value of *bhusa*. The cartage was 7 *pies* and marketing charges Re. 0-1-3. Deducting the total cost of Rs. 1-5-6 from the price per *maund* of Rs. 3-1-2, there was a profit of Rs. 1-11-8 per *maund* or Rs. 33-0-1 per acre. During the depression years from 1929 to 1938, the price of wheat at one time fell as low as Rs. 1-8. With a price of Rs. 2-2 per *maund* the net gain is only Re. 0-12-6. If net rent of land and land revenue, which of course have to be paid, are added there is a serious loss of Rs. 14 per acre.

An inquiry by the Imperial Council of Agricultural Research (1933 to 1936) showed the following average figures for wheat in the Punjab:—

Item.	*Lyallpur.*	*Jullundur.*	*Gurdaspur.*
	Rs. a. p.	Rs. a. p.	Rs. a. p.
Total cost per acre ..	43 2 1	66 4 0	30 6 2
Cost per *maund* ..	2 1 10	3 6 2	1 9 8
Market price of wheat ..	2 0 6	2 1 4½	2 0 4½

In Jullundur the cost is high owing to the high cost of irrigation.

BARLEY

Natural order .. *Gramineae*
Botanical name .. *Hordeum Vulgare*
Vernacular name .. *Jau*

The world's crop of barley is estimated to be about 1/3rd the weight of the world's wheat crop. But the acreage of barley in the world is only about one-quarter of that of wheat. In some places (*e.g.*, England) it can command a high price for malting in the preparation of alcoholic drinks particularly beer; in others a large area is grown because the climatic and soil conditions are not favourable to the growth of other cereals. Where neither of these causes comes into play the area of barley is generally but a small proportion of the cereal area and much smaller than the area of wheat.

Area.

In the whole of India the barley crop usually occupies about six million acres as against about 33 million acres of wheat. Most of this barley is grown in the United Provinces where the area of barley is nearly as great as that of wheat. The Punjab occupies a position of somewhat minor importance, the area in this province being about 808,000 acres or 13.5 per-cent. of the total acreage in British India and 8 percent of the Punjab wheat area.

Barley in the Punjab occupies 4.3 per cent. of the total area under *rabi* (winter crops) and 2.5 per cent. of the total cropped area. Before the first war period 1914-18 and up to 1930-31, the barley area used to be round about one million acres. Since then there has been a more or less permanent drop due mainly to an increase in the gram area.

Nearly 2/3rds of the total acreage under barley in the province is unirrigated and rest irrigated. Small areas are grown in most districts but Gurgaon, Hissar, and Ferozpure are the chief barley-growing Districts which account for 46 per cent of the total area. Gurgaon barley is much prized for its malting qualities—Farrukhnagar and Rewari being two important markets. The Districts of Kangra, Sialkot, Gurgaon, Muzaffargarh and Rohtak are next in importance. Climatic conditions govern distribution. Barley has the shortest growing period of any *rabi* cereal.

Classification.

Broadly speaking the Punjab barleys can be divided into two classes: (1) husked barley; and (2) huskless barley. These can further be divided into sub-classes according to the number of rows of spikelets in the ear and the colour of grains. Of these six-rowed husked barleys are most commonly grown in the Punjab though in some areas both husked and huskless barley may be grown.

The huskless barleys are neither grown nor marketed on any considerable scale anywhere in the Punjab. Only isolated fields are met with in the Province and the produce is locally consumed as a poor man's wheat. These barleys give low yield and are unfit for malting purposes.

Of the husked varieties, only six-rowed sorts are commonly grown in the Punjab. The two-rowed barleys give bold and plump grains, but their yield is not as high as that of the six-rowed varieties.

Of the husked barleys, type Nos. 4 (Rewari) and 5 (Lyallpur, E) are being recommended by the Department of Agriculture for cultivation in the Punjab. Both of these are pure-line selections from local mixtures and their various characteristics are given below:—

Type No. 4.—It is a six-rowed husked type with ears long and lax, kernels plump and heavy, husk yellowish and aleurone layer amber. It is very early in maturity, possesses a weak straw and long and broad leaves and is suitable for poor soils or for late sowings. It is very good for malting and brewing.

Type No. 5.—It is also a six-rowed husked type with short and compact ears, plump roundish and mediumly heavy kernels, husk brightly coloured and aleurone layer blue. Its leaves are dark green, long and mediumly broad, early habit of growth, semi-prostrate and straw thick, stiff and resistant to lodging and also to hails. It is late in maturity and is suitable for rich soils as it does not easily lodge. It is also fairly good for malting and brewing.

Type 5 is a heavier yielder than type 4 since it possesses a stiff straw and is resistant to lodging. In 1928-29 it yielded at the rate of 34 *maunds* per acre from an area of 5 acres. Type 4 too yields well, provided lodging does not take place.

Recently the manufacture of "Pearl Barley" has been taken up at Amritsar. For this purpose type 155-B and special two-rowed are considered better than the other varieties and it is possible that with the development of the pearling industry these types may gain ground.

Barley is everywhere regarded as a crop for light soils.

Conditions where grown.

In the Punjab it will grow well on soil that is too light for wheat and it will also give a crop where the soil moisture would be quite inadequate for wheat. It is thus mostly grown on light unirrigated land or on land which the farmer may or may not irrigate according to circumstances.

Season.

Barley is a *rabi* crop and it can be sown at the same time or even earlier than wheat, but it is usually sown later. In parts of the province where only small areas of barley are grown, it is sown chiefly on fields which are too late for wheat to be sown with good prospects. It is, thus, often sown as late as December or early January.

Barley is a much hardier crop than wheat and requires much less time for maturing. It ripens earlier than wheat and in most parts of the Province it is cut in the first days of April.

Seed rate.

The seed-rate of barley should be heavier than for wheat; in most districts it is 28 or 30 seers per acre. Since age impairs the germination, the seed used should not be old. The grain must also be well-developed and free from insect attack.

Mixtures.

In the chief barley-growing tracts of the Province, it is usually grown mixed with gram on light soils. On the heavier land to a very limited extent, barley is also sown mixed with wheat. These mixtures are favoured from the point of view of insurance against vagaries of weather; for gram will succeed where barley will practically fail for want of water and barley occupies much the same position in regard to wheat. The question of the soundness of the practice of growing these mixtures needs local experimental investigation. There is little doubt that many farmers have a very exaggerated idea of the increased yield obtained by this practice of growing one acre of mixture as against growing half an acre of each crop. And it must be remembered that when the grains are not separated by the farmer, but are sold in a mixed funerals. An estimate of quantities used for various purposes is given below:—

		Maunds.
(1)	Malting in the Punjab by the Murree Brewery	15,470*
(2)	Pearling	200†
(3)	Seed	405,070
(4)	Net exports	267,500
(5)	Feeding horses at Military stations ..	218,140
	TOTAL ..	906,380

After deducting this from the total production, the net balance of 3,666,170 *maunds* represents the quantity used for human consumption in the form of *chapatis*, *sattu*, *ghat*, cattle feeding and mixing with wheat in flour mills or *mandis*, etc.

Malting.

In the process of malting the barley is caused to sprout slightly, during which process the starch in the grain is changed into sugar. By subsequently fermenting the "malt" of sprouted grains the sugar is further changed and alcohol is produced. In malting, it would thus be obvious that the first requirement of grain is that it should have a very high "germinating capacity" (*i.e.*, a high proportion of living seeds capable of sprouting) and that the grains after moistening should all germinate equally rapidly. Assuming equal germinating capacities, the relative values of two samples of barley are usually considered in proportion to the relative contents of starch. Ordinarily, buyers are guided by the appearance of grain for this purpose, it having been found that a plump grain with thin transversely wrinkled skin, floury interior and bright yellow colour is the most suitable for malting. Shrivelled and discoloured grains affect adversely the quality and quantity of the finished product. A sample having 500 grains to an oz. is preferred by the Murree Brewery. The usual percentages of moisture and total

*3,010 maunds utilized by Solon Brewery is not included since it is outside Punjab.
† Amount utilized outside Punjab (Jammu State) has not been included.

nitrogen in the Punjab barleys are 10 and 1·8 respectively. But in dry season the nitrogen is somewhat higher, whilst in wet season it may fall to a little above 1 per cent. Barley, with such a low nitrogen content, is difficult to malt because low nitrogen means low yeast feeding property.

Barley suitable for malting can be sold in England at a price almost equal to that of wheat, and sometimes higher. The suitability of Punjab barley for malting is thus a matter of great importance. Punjab barley has not the appearance which is favoured in England for malting, but on the other hand it has a high germinating capacity and has good reputation among Indian brewers. Type Nos. 4 and 5 which are now recommended by the Agricultural Department are reported to be very good for malting and brewing by the London Institute of Brewing. In order to carry out further investigation into the malting and brewing qualities of the Punjab barleys a scheme of the Imperial Council of Agricultural Research has been in force for the last several years at Lyallpur.

Pearl barley is nothing more than the barley seeds without husk. The machine employed for husking works exactly on the same principle as the ordinary rice hulling machine, the only difference being that in the case of rice the material is passed through the machine 1 to 4 or 5 times whereas in the case of barley the material is passed 11 times through the machine in order to accomplish complete removal of the husk. For pearling a barley that has strong well developed, sound and whitish coloured grains with high nitrogen content is preferred. Weak grains are liable to breakage during the process of manufacture and the yellow or dark colour of the grain affects the quality of the pearl barley adversely. A concern at Amritsar known as Indo-Chemical Works Punjab, manufactured pearl barley, but the product was not as attractive in appearance as the foreign (Morton's, ètc.,) Pearl barleys. Another Firm at Jammu (Kashmir State) is manufacturing fairly large quantity of good quality barley powder and pearl barley. A *maund* of barley yields 18 to 22 *seers* of pearl barley. There is a wastage of 1 *seer* per *maund*, the balance being husk and barley flour. The price of Pearl Barley sold loose before the war was about Rs. 10 per *maund* whereas that of the husk and flour Rs. 1-8 per *maund*.

The relative feeding value of barley for animals is not greatly different to that of gram or cotton seed. But it differs from these in being more starchy in nature and in this respect more nearly resembles maize. It is thus more suitable for working cattle than for cows or buffaloes or growing animals, though there is no objection to its use for any of these. As a food it is believed to have a cooling effect, both on human beings and livestock. Crushed barley in the Punjab often forms the basis of the ration of grain for full grown horses, other grains being mixed with it according to circumstances. The barley fed to horses at Military stations is crushed at Moghulpura and Rawalpindi from where it is distributed among other cantonments. In Western countries barley is fed chiefly to fattening pigs and cattle.

Barley is everywhere regarded inferior to wheat as a food for human beings. This is due chiefly to the fact that barley-flour cannot be made into bread though a comparatively small proportion of barley-flour can be mixed with wheat-flour for bread making. Recent experiments conducted at Lyallpur have shown that 10—15 per cent barley can be mixed for bread and 15—25 per cent for *chapatti* making without any appreciable effect on taste. This finding was very helpful in taking short supplies of wheat during war a little further. In some European countries this has always been common practice. It is not a common practice in the Punjab. For flour making there is a further disadvantage attaching to barley in that it is more difficult to separate the flour from the husk and the amount of bran is higher. In some flour mills, however, barley is mixed with wheat for the whiteness of the flour.

A fairly large quantity of barley is also utilized in the form of *ghat* and *sattu*. The former is prepared by thoroughly roasting the moist grains and then removing the husk by pestle and mortar or rice husking machine. A *maund* of barley yields about 30 seers of *ghat*. The *sattus* are prepared by parching the under-ripe grains of barley and then grinding them in a mill; they are consumed by putting in water sweatened with sugar to taste. The wholesale prices of *ghat* and *sattu* before war was about Rs. 6 and Rs. 4-8 per *maund* respectively when the barley was selling at Rs. 2 per *maund*.

Cost (in "barani" areas) per acre

		Rs.	a.
Preparation of land for sowing	..	3	0
Seed	..	1	4
Harvesting	..	1	8
Threshing	..	2	0
Winnowing	..	0	9
Land revenue	..	1	8
Net rent	..	5	0
Total	..	14	13
Income			
6 *maunds* grains @ Rs. 2 per *md.*	..	12	0
8 *maunds bhusa* @ Re. 0-6-0 per *md.*	..	3	0
Total	...	15	0
Net profit per acre	..	0	3

RICE

Natural order—*Gramineae*

Botanical name—*Oryza Sativa*

Vernacular name—*Dhan, Chawal*

Area. This crop with an area of 80·5 million acres occupies 30 per cent. of the cropped area or 38 per cent. of the area under food grains in India. In the Punjab rice is generally unimportant occupying only 1 million acres or a little over 1 per cent. of rice acreage in India or 3 per cent. of the total cropped area of the Punjab. Of the total area under rice in this Province, 82 per cent. is irrigated and the rest is unirrigated. During the war years the area has risen to 1·2 million acres and the Punjab in 1944 exported 150,000 tons

In the Punjab, rice is mainly grown in Gujranwala, Sheikhupura and Kangra districts, which grow about 43 per cent. of the total rice in the Province. Karnal, Gurdaspur, Ambala, Sialkot and Dera Ghazi Khan grow another 32 per cent. The other districts that grow rice are Amritsar, Hoshiarpur, Lahore, Multan, Muzaffargarh and Montgomery.

Yield.

The average yield of paddy is about 14 maunds per acre, the average for irrigated areas being about 16 *maunds* and that for unirrigated lands about 7 *maunds*. The maximum yield so far obtained is 60.7 *maunds* per acre from *Jhona* 349 on 9/20th of an acre and 39·5 *maunds* from Mushkan No. 7 on ⅔rd of an acre at Kala Shah Kaku Rice Farm in 1938. This gives an indication of the scope for improvement. The outturn varies considerably from place to place and year to year. It is lower in the case of broadcasted crop than the transplanted one.

The total production of rice also varies considerably from year to year. During the quinquennium ending 1934-35 the average production in the Punjab was 465,000 tons. In 1944 the production rose to 654,000 tons.

Use of rice in reclamation of salt lands.

The Irrigation Department have been recommending rice as a very suitable crop to aid in reclamation of *kallar* land. It is estimated that 13 lakhs of acres are under *kallar* in the Punjab and that the area is increasing by 25,000 acres per annum. During the war large schemes sponsored by the Irrigation Department have been in progress, for reclamation, where extra water is supplied for the purpose. This has led to a substantial increase in the irrigated rice area. In this process rice is followed by berseem or gram.

Classification.

There are many varieties of rice grown in the Punjab and there is a good deal of confusion as regards their nomenclature. But broadly speaking they may all be grouped into three classes, *viz.*, fine, medium and coarse.

Fine rices.—***Basmati**, Mushkan, Hansraj* or ***Bara*** are included in this class. The kernels of these varieties are long and fine and elongate considerably on cooking without bursting of jackets. Individual kernels remains separate and there is a good deal of swelling in volume. On account of these reasons, these rices are high priced and are mostly consumed in cities by well-to-do people, particularly on ceremonial functions. They are also exported in appreciable quantities to cities like Bombay, Calcutta, Karachi, Hyderabad (Deccan) and Madras. They are commercially known as *Basmati*, "*Basmati* Dehra Dun", "Amritsari" or "Peshawari" rice. *Basmati* rice was originally grown in Dehra Dun and it is for this reason that Dehra Dun rice has become famous all over India. The average yield of these rices is about 14 *maunds*. The Punjab *Basmati* No. 370 evolved at Kala Shah Kaku Farm is claimed to be superior to Dehra Dun *Basmati* in all respects.

Medium quality rices.—This group includes *Palmal* and *Sone* varieties of rice. Of these the former possesses long slender and very attractive kernel, whereas the latter has comparatively small kernel. They are cheaper than *Basmati* but possess quite good cooking qualities. They are, therefore, consumed mostly by the middle class people.

Coarse rices.—These rices include *Jhona* varieties and are the cheapest rices in the Punjab. The kernels of these varieties swell considerably on cooking and thus produce the largest volume, which quality is greatly appreciated by poor class of people with whom quantity is often a greater consideration than quality.

Improved Varieties.—Work on the improvement of rice was started in 1926 at the Rice Farm, Kala Shah Kaku. As a result of selective breeding, the following improved varieties are recommended:—

370 *Basmati.*—It is the best cooking rice with white, long and slender grains. It responds well to manure and fertile soils, but is rather a late ripener and requires a good supply of water. It is easy to thresh, yet does not

shed in the field. It breaks considerably in husking. It is recommended for all places growing fine rice. The paddy fetches a premium of 2-3 *annas* per *maund* over local *Basmati.*

41 *and* 7 *mushkans.*—These varieties are liked for their flavour and sweetness. They are called *Lal Basmatis, i.e.,* red husked *Basmatis.* As a class they are less fine than *Basmatis,* but 41 *mushkan* owing to its long grain and good cooking qualitites fetches a good price. This variety is rather late, has a long transplanting season and has a tendency to lodge in rich, heavy and well manured soils. But it does not shed in the field and can withstand adverse climatic conditions and attack of rice leaf hopper better than other fine varieties, which factor is serving as a great impetus for the spread of its cultivation in place of *basmati* varieties in Sheikhupura and Gujranwala. The 7 *Mushkan,* though not so good in quality, is a better yielder than 41 *Mushkan.*

349 *Jhona.*—It is a coarse and heavy yielding variety. Its grain is fairly long and of good quality. It gives best results when transplanted early, *i.e.,* about the middle of June and does best in medium soils because in heavy and fertile soils it is liable to lodge. Its threshing is easy, but it is likely to shed in the field if harvesting is delayed after ripening. It is recommended for all districts except hills and inundation canal areas where water supply runs short early in the ripening season. Its paddy fetches a premium of 1-2 annas per *maund* over common *Jhona* in the market.

278 *Sathra.*—It is an early maturing variety taking 82-85 days in the field after transplanting. Hence it is recommended for growing in the inundation canal areas of the south-western districts of the Punjab. It is also reported to be less liable to attack by the rice stem borer which is a regular pest in these areas. It gives 3-5 *maunds* mathore n local varieties.

There are a few more varieties as well, which are showing great promise. Of these 246 *Suffaida* belonging to *Palmal* group deserves a special mention.

Soil.

Rice requires heavy soil and plenty of water for its growth. The *kallar* soil which will not grow other crops with advantage, will give a good crop of rice. For coarse varieties the soil need not be fertile, but the richness of soil is an important consideration for fine varieties like *Basmati.*

Season.

The sowing and planting of rice in the Punjab extends over more than three months. The seed is sown in nursery in May and June and seedlings are ready for transplanting from early June to middle of August. But the best time of planting is mid-June. Early plantings are good because there is a distinct increase in the length of the growing period. In the case of late sown crop, there is a marked decrease in yield. The crop is ready for harvest in the third week of September and continues up to the end of November. In the case of early sown crops, say in the first week of May, the harvest may start even at the end of August.

Recently the Department of Agriculture has evolved some varieties which ripen in July. It is, thus, now possible to grow one crop of rice from May to July and another from July to October, of course, on different pieces of land, in the rice growing tracts, irrigated by canals. With this arrangement on certain canals the area under rice can be doubled by utilizing the surplus summer water. There is, however, a risk of rice stem borer which may develop into an epidemic form and may ruin the second crop which is the main crop grown on a much larger area.

Rotations.

Largely rice is grown on the same land year after year. It seems these lands are able to keep up their fertility provided the water supply is adequate and unlike most of the other crops, quite good crops of rice can be raised continuously without any addition of manure.

Sometimes rice is followed by a leguminous fodder crop, such as *berseem* or gram.

Preliminary cultivation.

Rice does not require much of a fallow cultivation as is necessary for wheat. All over the Punjab in the rice growing tracts it is believed, and rightly so, that fallow cultivation of rice land is harmful for the crop. At the Kala Shah Kaku Farm it has been observed that fallow cultivation depresses the outturn of rice by about 30 per cent. The reason for this decrease in yield appears to be the washing away of nitrates which are formed in fallow cultivation, thus, leaving this land comparatively poorer than the land receiving no such tillage. An addition of farm-yard manure at the rate of about 240 *maunds* per acre, to the fallow cultivated land has, however, been found to make good this loss. More work needs to be done in the study of nitrogen requirements of rice.

Preliminary cultivation of rice crop is thus mainly done in the standing water. The common practice with the farmers is to irrigate the land heavily, plough it up when it comes in *vattar,* flood the land again and leave it as such for about a week after which it is ploughed again and pegged *sohaga* or *dandal* is run in water. Just before planting a few more stirrings are given so that the rice field is thoroughly puddled and mire is as fine as possible.

Four to six ploughings and cross ploughings followed each time by *dandal* are considered to be sufficient for bringing the land to suitable condition for sowing.

Seed rate.

There are two methods of sowing rice,—*viz.*, broadcasting and transplanting seedlings grown in the nursery. In the case of former the seed rate is about 10-12 *seers,* but in the case of latter method which is considered to be superior and is generally practised in the Punjab, 2½-6 *seers* of seed sown in 2-4 *marlas* give enough seedlings for one acre. In Kangra District where it is sown by broadcast, the seed rate goes even to one *maun* per acre.

Raising seedlings.

There are two methods of raising rice nurseries in the Punjab (1) dry method and (2) wet method. In the first case the seed is scattered at the rate of one *seer* per *marla* on a sufficiently manured and well prepared piece of land. The seed is covered with a fine dressing of farmyard manure and water is applied gently. Later on water is given whenever necessary, taking care that the plot is neither too wet nor too dry. The seedlings are ready for transplanting in about 5-6 weeks' time when they are about 10-12" high. In the case of wet nursery a well levelled piece of land is heavily irrigated. When the land is still wet it is ploughed and water is applied again to cover the soil surface so as to kill the weeds. Later on at short intervals 5-6 ploughings and 3 *sohagas* are given in the standing water and fine puddle is produced. Then the seed is sown by broadcast method in the seed-bed covered with a fine film of water. This water is, however, drained off in the evening and next morning water is again applied. This process of draining off water in the evening and applying fresh water in the morning is continued for a week or so. By this time seedlings attain a height of about 2" and water is then allowed to stand constantly in the field. The seedlings get ready for transplanting in about 3-4 weeks' time. In the case of wet nursery nearly always sprouted seed is used. For this purpose it is soaked in water for 24 hours, and then covered over in a heap with wet gunny bags under shade for about 36-40 hours.

Dry nursery requires a lot of manure and takes longer to grow. Wet nursery gets ready in much less time, *i.e.*, about 15-20 days earlier than the dry nursery.

Transplanting.

Seedlings are transplanted singly in the standing water at a distance of about 9 inches from plant to plant. Usually hired labour is employed for this purpose at the rate of Rs. 2-8 per acre when seedlings are lying in the field. If removal and transport of seedling is to be done, Re. 0-12-0 more are needed. During the war the rates increased to Rs. 10 per acre.

Irrigation.

Rice is a semi-aquatic plant; practically water should always be kept standing in the crop. Timely refreshing of water is, however, very necessary and after about 40 days from transplanting the rice field should be kept drained for about 5-7 days. This is very beneficial because lodging is considerably reduced. Then again in order to facilitate the harvesting of crop water should be drained off about a fortnight before ripening. The total requirement of water may be taken to be about 60" or 20 irrigations. But the quantity of water required depends upon the soil conditions and variety of rice grown.

Weeding.

One to two weedings should be done to keep down the rank growth of weeds.

Pests.

The most serious pest of this crop is rice stem borer. It causes heavy losses every year particularly in Muzaffargarh and Dera Ghazi Khan districts. The damage done is most in case of late varieties where in some fields even 87 per cent. of the crop is affected. In order to control this pest effectively, early ripening varieties should be grown and late sowings should be avoided. Since the caterpillars of this pest hibernate in the rice stubbles during the winter season, they should be uprooted before the month of March, carefully collected and burnt.

Harvesting and threshing.

The harvesting is almost exclusively done by manual labour. The crop is cut by sickle as in the case of wheat. It is then collected in a convenient place in the field and is immediately beaten out by striking the sheaves against a small mud *bund* erected for this purpose. Harvested crop should not be left in the field over night because dew is said to have a deteriorating effect on the grain and increases its liability to break during subsequent operations. In the Kangra district threshing is done by means of bullocks. The straw, however, does not break up into *bhusa* like wheat or barley. It is used mainly for animal feeding and bedding, and as packing material. The straw would perhaps be put to better use by making baskets and hats, as is done in China and Japan.

Winnowing is done by means of *chhaj* in the same manner as described under wheat.

Harvesting, threshing and cleaning of rice is usually done on contract in kind which varies from 3 seers to 3 seers 6 chhattanks per maund according to easy or difficult threshing.

Drying.

Paddy contains a considerable amount of moisture after it has been gathered and has to be dried before it is fit for husking. The drying is done by spreading it on floor and exposing it to the sun for about 6-10 days in winter depending upon the variety of paddy and season, and frequently stirred to ensure uniform drying. In the evening the paddy must be collected into a heap and covered with thick cloth or *tirpal* and next morning spread again. If allowed to remain exposed at night there is a considerable breakage during husking.

The drying is usually done by *Kashmiri* labourers who are paid at the rate of Re. 1 to Rs. 1-4 per 100 bags. During war these wages have increased three times.

Hulling.

After threshing the husk remains attached to the grain. It is separated by means of hulling machines driven by oil or steam engine or electric motor. Before the introduction of these machines paddy was hulled by pounding with a pestle in a mortar (*ukhli*, *mohla*) as is commonly done even now in the rural areas of Kangra and some parts of Karnal and Ambala districts. At some places husking is done by means of special hand-driven *chakkis*. The food values of the home-pounded and milled rices, as given in Health Bulletin No. 23, are given below:—

Particulars	Rice, raw		Rice, parboiled	
	Home-pounded	Milled	Home-pounded	Milled
Moisture percentage ..	12·2	13·0	12·6	13·3
Protein percentage ..	8·5	6·9	8·5	6·4
Fat percentage ..	0·6	0·4	0·6	0·4
Mineral matter percentage	0·7	0·5	0·9	0·8
Carbohydrate percentage ..	78·0	79·2	77·4	79·1
Ca. percentage ..	0·01	0·01	0·01	0.01
P. percentage ..	0·17	0·11	0·28	0·15
Iron (mgs.) percentage ..	2·2	1·1	2·8	2·2
Carotene (International Vit. A units per 100 grms.) ..	0·4	0	15·0	0
Vit. B. (International units per 100 grms.) ..	60	20	90	60

It will be observed from these figures that the parboiled rice is much richer in mineral matter, P, Iron, Carotene and Vit. E contents than the raw rice, and the hand-pounded rice, whether parboiled or raw, has got a higher feeding value than the milled rices.

About 60-70 lbs. of grain is obtained from 100 lbs. of unhusked rice, but this ratio varies with the variety. In the case of coarse varieties, about 26 *seers* of rice (including broken rice) are obtained from one *maund* of paddy, whereas in the case of fine varieties like *Basmati* the yield is about 25 *seers*. The remaining portion, *i.e.*, husk is commonly called *phak*. It is sometimes graded into classes and sold at varying rates. But the usual rate is about Re. -/3/- per *maund* for mixed stuff.

Parboiled rice (*Bila chawal*).

The parboiling in rice is done in almost all important places in the rice growing tracts. But in the Gujranwala and Sialkot districts the parboiled rice is prepared from fine and medium varieties, whereas in the south-western districts coarse varieties are used for its manufacture. There is a general prejudice amongst Hindus against the use of *sela* because they do not eat anything which has been cooked previously by unknown person. It appears, however, that this prejudice is disappearing gradually.

The methods employed vary from place to place, but broadly speaking they can be divided into three classes. In the Muzaffargarh and Dera Ghazi Khan districts the paddy is put along with water in big earthen pots placed on a thick layer of rice husk set on fire. The heating is continued for about 24 hours after which the paddy is removed and roasted in sand over an iron pan for about 5 minutes. The roasted stuff is then spread to cool and subsequently husked. Since, this process is laborious, it is usually done by hired labourers who charge at the rate of Re. 0-2-0 per *maund* of paddy (pre-war) for all this work. In Sialkot, Dina Nagar, and Mukerian the paddy is soaked in big iron tanks for 48 hours after which it is roasted and spread to cool. At Akalgarh and Kamoke the paddy is soaked in iron tanks and heating done by means of steam for 24 hours. After this the hot water is drained off and paddy is taken to small tanks where it is dried again by steam.

The first method is rather crude, but the rice obtained is of excellent quality, it does not give bad smell when cooked and kept for some time, which is the common drawback in the parboiled rices. Of the other two methods, the one in which the paddy is roasted in iron pan, does not give uniformly heated rice.

Storage.

Paddy is not stored for long or in large quantities in the villages and earthen pots are generally used for storing the requisite small quantities. Nearly 83 per cent. of the total production is sold by the cultivators within the first four months of harvesting.

In the markets paddy is generally stored in bags, though rarely it may be stored in bulk in the ordinary houses having pacca floors. Great care is, however, necessary in this case as exposure to elements increases the liability of grains to breakage.

Rice improves in quality with age. It is generally believed that this improvement is continuous up to 4 years or so and it is for this reason that old rice sells dearer than the new rice. Before the war the price of new rice was Rs. 4-14-0 per *maund* whereas that of a year old rice was Rs. 5-8-0 as against Rs. 6 and Rs. 6-7-0 per *maund* for two and three years old rices respectively.

Uses.

Rice is mainly used for cooking purposes but a fair amount is also eaten in the form of roasted products like *marunda, phullian, chirva* etc. mostly in towns and cities. A considerable quantity of broken rice is also used in laundering.

Trade.

The Punjab in pre-war period was only a slightly surplus area, but there was a considerable exchange of rice with other provinces. During the year 1938-39, the exports from the Punjab Trade Block amounted to 1·63 million *maunds* whereas the imports were 1.34 million *maunds*. The exports mainly consisted of fine rices which go mostly to U. P. and Rajputana which absorb nearly 2/3rds of the total exports. Some goes as far as Hyderabad and Madras. The best rice is, however, sent mostly to big cities as mentioned before. The imports mainly come from Sindh, British Baluchistan, U. P. and Bengal. Since the loss of Burma rice in 1942 the exports from the Punjab have risen steadily to over 150,000 tons per annum. No imports were allowed during the war.

The intra-provincial movement of rice also takes place on a fairly large scale. Gujranwala, Sheikhupura and Sialkot are the chief exporting districts, whereas Jullundur, Ludhiana and south-eastern and north-western districts of the Punjab are solely the importing areas.

Cost of cultivation.

In order to find out the cost of production of an acre of rice, the cost of raising nursery must be estimated. Accordingly an estimate of raising one *kanal* of nursery by wet method is given below:—

		Rs.	a.
Preparation of land—6 ploughings and *sohagas*	..	1	8
Seed 20 *seers* at Rs. 3 per *maund*	..	1	8
Sprouting of seed and broadcasting	..	0	3
Water, draining and care of nursery, etc.	..	0	9
Total	..	3	12

This works out to Rs. 0-3-0 per *marla*.

The cost of cultivation of an acre of transplanted rice is estimated as follows:—

	Rs.	a.
Preparation of land —6 ploughings and *sohagas*	12	0
Strengthening of *bunds*, etc.	1	0
Cost of 5 *marlas* of nursery at Re. 0-3-0 per *marla*	0	15
Pulling out of seedlings	1	0
Transplanting, 5 men in one day ..	3	4
Watering and draining (1 man at Rs. 12 per month for 3½ months to control 20-25 *acres*)	2	0
Harvesting, threshing and cleaning at 3 *seers* per *maund*	3	12
Cartage	1	0
Water Rate	6	8
Land Revenue	3	0
Net rent or rental value of land ..	7	0
Total ..	41	7

Taking average outturn of rice on irrigated lands as 16 *maunds*, the gross income at the present rate comes to Rs. 48 per acre. To this if we add Rs. 2 as the value of straw, the total income amounts to Rs. 50 thus giving a net profit of about Rs. 8-9 per acre.

MAIZE, JUAR AND BAJRA

Distribution.

These three crops fulfil similar functions in the various districts where they are grown, and are, therefore, grouped together. Maize is grown where rainfall or irrigation is plentiful; *bajra* in the dry parts of the Ambala and Rawalpindi Divisions, where it is a very important crop; *juar* occupies an intermediate position, being less drought resistant than *bajra*, but much more so than maize. All three can be grown either for grain or for fodder; in the latter case they are sown more thickly, though in dry years crops grown for grain are often used as fodder. The stalks of these crops obtained as a by-product in the production of grain are also used as fodder. Of these *juar* stalks are considered to be the best and those of *bajra* the worst, maize stalks coming in between the two. *Juar* stalks can be stacked and stored as *karbi* for several years. The *bajra* stalks are sometimes used even as fuel in times of scarcity. In the Canal Colonies, maize is chiefly grown for grain, whereas *juar* is almost exclusively grown for fodder (*chari*) generally as a mixture with *guara.*

MAIZE

Natural Order—*Gramineae.*

Botanical Name—*Zea Mays.*

Vernacular Name—*Makai.*

Maize is a *kharif* cereal. The original home of this crop seems to be tropical America. When it was brought to the Old World is not definitely known.

Distribution.

Maize is extensively grown in tropical and subtropical regions of the world. The United States of America is the biggest grower of maize, having about 91 million acres under it. Next comes Rumania with 12 millions, and Argentina with 11 millions. India along with South Africa comes 4th. In respect of yield, however, India and Africa occupy the lowermost position with about 9 *maunds* per acre, as against 27 *maunds* in Egypt, 22 in Italy, 21 in Hungary, 20 in Argentina and 16 in United States of America. As India was a big importer of corn products before the war, it is desirable that yield of maize in India should be increased. The scope for increasing the yield lies in the evolution of new varieties by scientific breeding as described later on.

In India maize is mainly grown in the United Provinces, Bihar and Orissa, Punjab, Hyderabad State and N.W.F.P. The Punjab grows about 17 per cent of the total area in India.

The Districts of Kangra, Hoshiarpur, Jullundur, Ambala, Gurdaspur and Ludhiana are the chief maize producing districts in the Punjab, mentioned in the order of their importance. Other Districts where maize is of some importance are Rawalpindi, Amritsar, Karnal, Lyallpur and Ferozepore. The chief markets for maize are Jagraon, Ludhiana and Moga.

Area.

The total maize acreage in India is about 6·3 million acres (1936-37 to 1940-41 · average). Of this about 1·1 million acres, *i.e.*, 17 per cent. are grown in the Punjab. About 52 per cent. of the area in this province is unirrigated and the remaining 48 per cent. irrigated.

Maize covers about 4 per cent. of the area of crops sown in the Punjab. Like sugarcane, however, maize is more important than this figure appears to indicate, especially for some districts where it is chiefly grown. Maize is a popular and profitable crop in places where it can be grown without irrigation. Excepting some river beds, this is possible only where the monsoon is fairly early and reliable. Thus in districts such as Kangra, Hoshiarpur and Ambala considerable areas of maize are grown without irrigation or manure. In such circumstances the crop is profitable even if the yield per acre is not high. But if the crop has to be irrigated, it is grown only where irrigation water is available fairly cheaply and the standard of farming is fairly high. Thus, maize is regularly grown on small areas in districts like Jullundur and Lyallpur, where the yield is commonly upwards of 20 *maunds* per acre. Outside the areas mentioned already maize is of little importance. In many districts the crop is hardly to be seen at all.

Competing Crops.

Cotton is the chief crop in Canal Colonies with which maize has to compete for area. Although sugarcane is also a heavily manured crop, there is practically no competition between sugarcane and maize, because sugarcane is seldom manured directly. The latter is usually grown on land which has just produced a heavily manured crop, residual manure being considered better for sugarcane than direct manuring. Maize is a particularly suitable crop to precede sugarcane in the rotation. These two crops do not compete unduly for water supply as well. Sugarcane needs more water from May to July, while maize requires most water during the later months, *i.e.*, from July to October.

Where cotton does not do well before sugarcane then maize is the most profitable *kharif* crop, provided, of course, the land is good and water supply sufficient and regular for its growth. Cotton yields well only in the comparatively low rainfall districts. In such places maize has to be irrigated. Under such conditions the relative prices of cotton and maize influence the relative area of these two crops.

Varieties.

There are two main varieties of maize—yellow and white. Out of these the former is grown to a much greater extent in this province than the latter. The yellow type is predominant in the Eastern, Central and Canal Colony districts, while the white type is important in the western districts adjoining the N.W. F.P., where it is the dominant type. Yellow maize is commonly said to be sweeter and more tasteful than white, but the latter is preferred for roasting, popping and manufacture of starch. White type is said to be more drought resistant and ripens earlier.

Sweet Corn.

A garden variety has been developed in America which is much prized when roasted and served in hotels and private houses as a savoury with butter and condiments. This variety can often be bought in Simla and in the private gardens of American Missionaries. It is very profitable when a good market is available. Its yield per acre is low compared to the domestic types.

Preparation of seed bed.

The soil is usually thoroughly prepared for maize by several ploughings.

Soil.

Maize prefers a heavy or heavy loam soil. It is practically never grown on sandy soils.

Sowing season.

When grown for fodder the crop may be sown as early as March or April and the fodder is ready in $1\frac{1}{2}$ to 2 months. The grain crop is sown in late June or early July in the central districts. In the hills it is sometimes sown as early as May and in the canal colonies as late as August. When sown for the sale of cobs in the towns, sowings may be done from March to August, the months of July and August being most important.

Rotations.

In the plains, maize is commonly rotated with sugarcane, cotton or wheat. It is followed by wheat only on land irrigated by wells, where it is sown early, and very rarely in the canal colonies. The *rabi* crops, which are most often sown after maize are *senji* on irrigated land and lentils (*massar*) on unirrigated lands. The next *kharif* crop may be either cotton or sugarcane. In the hills and some submontane places maize is often rotated with potatoes.

Manuring.

Irrigated lands reserved for grain crop are heavily manured, the general practice being to put 20 to 30 or even more cartloads per acre, especially if maize is to be followed by sugarcane.

Seed Rate.

The usual seed rate of maize is 6 *seers* per acre for the grain crop and 12 *seers* for fodder. There is, however, a considerable variation from this figure in certain localities.

Method of sowing.

In higher altitudes and submontane districts where the crop is usually grown without irrigation, it is generally sown broadcast. On irrigated lands the grain crop is usually sown by *kera, i.e.,* by dropping seed behind the plough. Even in these tracts, however, the fodder crop is sown broadcast. When grown for the production of grain, maize must be well spaced, as this ensures good development of cobs.

Watering.

The first watering after sowing should be delayed as much as possible. In the absence of rain maize may need irrigation as frequently as every 10 days during the 6 weeks of its most rapid growth. When very young, or when almost ripe the crop requires less frequent irrigation.

Interculture.

The grain crop usually receives three or four hoeings.

The most important pest of the crop is the stem borer

Pests and diseases.

The damage done by this pest in certain localities, such as Montgomery and Multan is so severe that the zemindars have given up growing maize fodder. There are three distinct species of borers, but the most important of these, and the one mainly responsible for the damage is *Chilo Zonellus*. The insect is directly harmful in its caterpillar stage, when it eats leaves and bores into the mid-rib of leaves and into stems, tassels and even cobs. The most serious damage is inflicted upon the young crop. The fact that these insects make their winter abode in the stubbles, which are left in the field after the crop is cut, suggests a most effective method of combating these borers. If the stubbles harbouring the hibernating borers are destroyed, the pest will be killed. All remnants of last year's crop of maize, *jowar*, *bajra*, sugarcane, *baru* grass, etc., which harbour the pest, should, therefore, be completely destroyed. This should be carried out collectively over large areas, and fields ploughed and cleaned before the middle of March. Cultivators sometimes collect such stubbles and heap them in their fields. This practice is of no use as the hibernating caterpillars remain alive. On emergence the moths lay eggs which on hatching start their work of devastation.

Harvesting.

The maize crop ripens in about 3½ to 4 months. The harvesting takes place in the second half of September in the hills, in October in the central districts, and as late as November in the canal colonies. The crop meant for the sale of cobs is used about a month earlier.

Maize is harvested when ripe, *i.e.*, when the cob-sheaths turn brownish, and the grain is fairly hard. After harvesting the plants are left lying in the fields for two to three days, before they are stacked. The crop remains in the stacks (called *muharas* or *munaras* in the vernacular) for about two to six weeks. During this period unripe cobs get a chance to further ripen, and the grains lose their excesssive moisture. Cobs are then separated from the plants and spread out in the sun to dry up. The grains are separated from the cobs by beating.

Maize seed for the next year's crop is invariably kept in the form of cobs. Grain from these cobs is not beaten out for sowing purposes, but is removed by hand just before sowing. Beating is said to injure the embryos and impair the germination capacity.

Yield.

When irrigated and manured the yield of an average crop is about 24 *maunds* per acre. Under especially favourable conditions, *i.e.*, when the crop is heavily manured and amply watered and other conditions are also suitable, as much as 40 *maunds* per acre may be obtained. The unirrigated crop which is usually also unmanured, on a fairly good field may be taken to yield 10 to 12 *maunds* of grain per acre. The average yield in the Punjab, as judged from the statistics of crop returns, is 9·9 maunds per acre (1936-37 to 1940-41 average), as against 9·4 maunds per acre for the whole of India and 21·2 *maunds* for U.S.A. (1939 to 1942).

Marketing.

The Punjab produces about 457 thousand tons of maize annually (1939-40 to 1943-44 average). It has been estimated that about 85 per cent. of the maize produced is retained in the villages for seed, human consumption and feeding to livestock, and only 15 per cent. is sold out. Practically the whole of the surplus is marketed within 5 months of the harvest, *i.e.*, from October to February. Very small quantities of maize are carried over from one year to another, most of the production of a harvest being consumed in the winter season. Long storage in the case of maize is not desirable, as the quality of grain deteriorates after a short time. The colour of the grain gets dull and the taste is spoilt.

The Punjab is, on the whole, a net importer of maize. The net imports were estimated during the year 1935-36 to be 54 thousand *maunds* grain, 7 thousand *maunds* flour and 25 thousand *maunds* starch. The chief sources of imports of grain were found to be the N.W.F.P., and Malerkotla, Patiala and Kapurthala States. Small quantities exported from the province go mainly to U. P. and Bilaspur, Poonch and Mandi States. Since the war up to 8,000 tons are occasionally exported.

Uses. By far the largest amount of maize crop is consumed as human food. This is chiefly done after converting it into flour and making *chapatis* out of the flour. To some extent it is also consumed as roasted and popped grain. Some percentage of maize crop is used as poultry and livestock feed. and for the manufacture of starch required for use in the textile mills, paper mills and other industries. White maize is preferred for starch manufacture. In U.S.A., starch is made out of maize for industrial purposes. and large quantities of it are imported into India. Starch and corn flour manufacture has recently been taken up in India also. There is one mill in Jagadhri working for the past several years. One has recently been started in Faridkote State. one in Patiala State and one in Kapurthala State.

The grinding of maize is considered to be more difficult than that of wheat or gram. The grinding charges for maize are, therefore, about 1½ times of those for wheat or gram.

The demand for maize is considerably influenced by the comparative prices for maize and other cereals, particnlarly wheat.

Maize fodder. Maize is to some extent used for fodder. In this respect it is especially useful for sowing in the early part of the *kharif* season, as at this time of the year it grows quicker than *chari*. It is thus sown in late March or April usually mixed with *swank* and *moth*. Cowpeas also form a good mixture with maize. As fodder, it is sown broadcast. Later in the season it is sometimes sown mixed with *chari*.

Even in the case of maize grown for the production of grain, the stalks are fed to cattle.

Method of seed selection. As stated earlier, maize plant is subject to extensive cross-pollination. Mass selection has, therefore, been practised since earliest times. The farmers can, however, do much to keep the seed up to the standard and even improve it by proper selection of seed. The method that can be recommended to the farmers is mass selection. This method consists in picking out cobs having desirable characteristics for seed purposes.

This can best be done while the crop is standing in the field. When selecting cobs for seed the following points should be kept in mind :—

(1) Plants growing under normal conditions of competition should be selected. Plants along the borders and water channels should be rejected.

(2) Plants in the vicinity of diseased plants should not be selected.

(3) Plants bearing more than one good cob should be preferred.

(4) Ears that are not only thoroughly mature, but also ripen at the same time should be selected. This will tend to bring about uniformity in the ripening time of the next crop.

(5) It is desirable to collect ears from plants bearing them at a height of about 3 to 4 feet. If placed higher the plants are liable to be damaged by storm, while if placed too low wild animals like jackals will cause havoc.

(6) The cobs should be long and cylindrical with butts and tips well filled in. Uniformity of size and colour of the cobs and compactness of grain on cobs should be preferred.

(7) In *barani* areas narrow leaved plants should be preferred while for irrigated conditions broad leaved varieties should be selected as they usually give higher yields under these conditions.

(8) About two to three times the quantity of cobs required for seed should be selected to allow discarding of diseased and defective ears.

(9) Soon after collection the ears should be cured properly, *i.e.*, dried in a single layer. Heaping of the ears even for a short while should be avoided, as this practice lowers the germination capacity of the seed.

It is highly desirable that selection of cobs should be made from the standing crop, but if this is not done, selection of cobs may be made from the harvested crop as a less desirable alternative.

Another method of breeding practised on this crop has been what is known as ear to row selection. It aims at estimating the potentiality of each parent plant. The results of this method practised for a long period have been rather disappointing. With the advance in genetical knowledge of the maize plant a new method has been adopted which attempts to rebuild the constitution of the plant, so as to incorporate a majority of the desirable factors from the best material available. This is affected by (*a*) inbreeding and, (*b*) recombining the products. The method consists in controlled self-pollination of maize plant for 5-7 generations followed by selection among the resulting inbred lines and thereafter hybridisation between them for determining the most productive F1 combination and production and use of those combinations year after year for the production of commercial crops. Following this method in United States of America the hybrid corn has definitely established its superiority.

The improvement of maize crop in India by the method discussed above has been taken up under a Scheme jointly financed by the Punjab Government and the Imperial Council of Agricultural Research at Lyallpur under the immediate supervision of the Cerealist.

Cost of production.

An estimate of the cost of cultivation per acre of maize on a well-irrigated holding is given below:—

		Rs.	a.	p.
1.	Ploughings 4 @ Rs. 1-8 each ..	6	0	0
2.	*Sohaging* 2 @ Re. 0-6-0 each ..	0	12	0
3.	Sowing with *kera* 1 man @ Re. 0-8-0 per day (Ploughing included above).	0	8	0
4.	Seed: 6 seers @ Rs. 3 per maund ..	0	7	2
5.	*Bundmaking* 1 man @ Re. 0-8-0 each	0	8	0
6.	Waterings 5 @ Rs. 3-4 each ..	16	4	0

		Rs.	a.	p.
7.	Hoeings 3 at 4 men per hoeing @ Re. 0-8-0 per day each	6	0	0
8.	Harvesting: 3 men @ Re. 0-8-0 each	1	8	0
9.	Plucking cobs 3 men @ Re. 0-8-0 each	1	8	0
10.	Threshing 3 men @ Re. 9-8-0 each	1	8	0
11.	Manuring 10 cartloads utilised (the total being 20) @ Re. 1 per cart load	10	0	0
12.	Land Revenue	3	0	0
13.	Rent	12	0	0
	Total ..	59	15	2

Income.—

	Rs.	a.	p.
Grain 20 *maunds* @ Rs. 2-8-0 ..	50	0	0
Stalks 20 *mannds* @ Re. 0-8-0 per *maund* ..	10	0	0
Total ..	60	0	0
Net Income ..	0	0	10

JUAR

Natural Order—*Gramineæ.*
Botanical Name—*Andropogan sorghum.*
English Name—*Great Millet.*

Distribution.

Juar is extensively grown in Bombay, Madras, C.P., Berar, and U. P. noted in the order of their importance. The Punjab occupies the fifth position. In Western India both *kharif* and *rabi* types of *juar* are grown, but in the Punjab only *kharif juar* is known. For grain purposes the crop is mainly, more than three-fourths of the total area, grown under *barani* conditions. The total area during the last decade has been generally between 8 and 9 lakh acres, though in some earlier years the area under the crop was even above 1½ million acres. Wide fluctuations in area are mainly due to seasonal variations from year to year.

The largest area under *juar* is grown in the districts of Dera Ghazi Khan, Rohtak, Hissar, Karnal and Gurgaon, in the order mentioned. The other districts where it is grown to a lesser extent are Multan, Rawalpindi, Attock, Mianwali, Jhang, Ferozepur and Muzaffargarh. For fodder purposes in the canal colonies, *juar* is generally mixed with *guara*.

Seed Rate.

For grain about 8 *seers* and for fodder 24 *seers* per acre are generally sown.

Cultivation.

Two to four ploughings are given as a rule. The cultivation is not as thorough as for maize. It is generally sown broadcast, and is often mixed with *guara*, *moth*, *mash*, *mung*, *lobia* or *til*. The common rotations are:—(1) cotton-*juar*, (2) wheat-*juar*, (3) cotton-*juar-sann* ploughed in wheat, and (4) gram-*juar*.

It would thus be seen that *juar* generally follows cotton, wheat or gram.

Sowing time.

For grain the crop is sown with the outbreak of monsoon rains. The normal time is from middle of June to middle of July. If rains are late, it may be sown even up to middle of August. For fodder purposes it can be sown as early as the end of March or April. *Juar* takes about $2\frac{1}{2}$ to 3 months for ripening. In the south-eastern tracts it ripens a little earlier.

Harvesting.

Starts from the end of September and continues up to the end of November. Harvesting is done with sickle, and the plants are allowed to remain on the land in the form of sheaves for a few days. After tying into bundles they are put in stacks. The plucking of heads is done mainly with the help of female family labour at leisure. If hired labourers are engaged they are paid in kind. Usually 5 to 6 labourers are sufficient to finish an acre in a day. The grain is then threshed out of the heads by means of the bullocks. If the quantity to be threshed is small the grain may be beaten out by means of sticks. Three men and three bullocks are required for threshing a normal acre crop. The winnowing work is similar to that of wheat. A steady wind of fair strength is best for winnowing.

The average yield on *barani* lands where *juar* is generally sown is about 5 *maunds*, whereas, under the irrigated conditions 8-10 *maunds* per acre are obtained. The maximum yields on irrigated areas are obtained in Rohtak and Jhelum districts and in *barani* areas in Gurgaon and Gujrat.

Yield.

Based on the colour of grain, three types are recognized by the farmers and the trade:—1. red, 2. *sharbati*, and 3 white. White *juar* always brings premium over the other two. These types can further be divided into small and bold grains.

Varieties.

The grain is sometimes extensively damaged by smut or bunt as in the case of oats. Treatment of seed with copper sulphate solution, ½ per cent. strength is effective in preventing the appearance of smut. Striga root parasite also causes considerable damage to *juar* crop in some districts, particularly Gurdaspur and Gujranwala. Sometimes with untimely rain, seed formation is affected adversely in the Punjab and seed for the following season is expensive and difficult to secure, except by importing in large quantities from other areas, especially Central India and Sind. Within the Province D.G. Khan can supply good quantities of *juar* seed but the trasnport is rather difficult, due to lack of good communications.

Diseases.

The *juar* grains are mainly used as seed for the raising of fodder or grain crops, though in districts of Dera Ghazi Khan and some north-western districts it is used for human consumption. When wheat sells at a higher price, the *ata* made from white *juar* grain is used for the adulteration of wheat *ata*. *Juar* grains are also commonly used after roasting or popping. The food value of *juar* may be seen from the following table:—

Use.

Crop.	*Protein.*	*Starch.*	*Oil or fat.*
	Per cent.	Per cent.	Per cent.
Juar	9·3	72·3	2·0
Rice	7·3	78·3	0·6
Wheat	13·5	68·4	1·2
Oats	3·1	56·0	2·3

Research work for the improvement of millets was started at Lyallpur in 1927 when a special officer was appointed. He continued to work at Lyallpur up to 1934 when his work was shifted to Sirsa (Hissar). Later on, in March 1940, his headquarters were transferred to Ferozepore to carry on the work under *barani* conditions. The most important variety evolved is J-8. It is a dual purpose type, good for both grain and fodder. It possesses lax heads of medium size borne on straight peduncles. The grain is of an attractive creamy white colour and of medium size. The glumes are slightly purplish at the base and possess very short awns. The crop grows to the height of 8 to 10 feet depending upon the fertility of the soil. The stem is thin and juicy. The leaves have yellowish green mid-rib; a character correlated with the sweetness of the stem. The crop remains green for a fairly long time even after grains have matured. It yields 15 to 18 *maunds* of grain with 100—125 *mds*. of *karbi* or about 400 *maunds* of green fodder per acre.

Research Work.

Since the crop is cross-pollinated, the seed should be selected from year to year by the mass selection method. This is a simple method and can be practised by ordinary cultivators. The points to be borne in mind are (1) select normal heads which ripen uniformly from the healthy standing crop and avoid the plants growing at more favourable places; (2) select heads which are well developed, well filled and dense with bold and round grains; (3) avoid diseased plants and also plants in the vicinity of diseased plants.

BAJRA

Natural Order—*Gramineæ*.
Botanical Name—*Pennisetum Typhoideum*.
English Name—*Bulrush or Spiked Millet*.

Bajra is extensively grown in Bombay, Punjab Madras, and U. P. named in the order of importance. *Bajra* is more important crop in the Punjab than *juar*. The area fluctuates enormously from year to year, being as high as 44 *lakh* acres in some years and only 11 *lakh* acres or so in years of poor

Distribution.

rainfall. Since it is practically a *barani* crop, season from year to year affects its sowings considerably.

The important districts growing *bajra* are Hissar, Gurgaon, Rohtak, Attock, Jhelum and Gujrat in the order named. The other districts where it is grown to a fair extent are Ferozepur, Shahpur, Rawalpindi, Karnal, Mianwali, Sialkot, Dera Ghazi Khan, Gujranwala, Multan, Lahore and Jhang. Very little is grown in districts of Jullundur, Ludhiana and Lyallpur.

Soil. *Bajra* will grow on poor sandy soils whereas *juar* requires a stiff loam. Maize will do well on good stiff loams.

Seed. The seed rate is two to four *seers* per acre.

Sowing and harvesting season. As in the case of *juar* the sowing season, depends upon the outbreak of monsoon. The sowings generally commence from early June and continue upto the end of July or at the latest beginning of August. Harvesting of *bajra* begins from middle of September and continues up to early November.

Cultivation. Cultivation of *bajra* is similar to that of *juar*, but it can stand rough conditions better than *juar* as it is a very hardy crop.

Yield. The average yield on the unirrigated area is four to five *maunds* per acre, and that on irrigated areas six to ten *maunds*. Highest yields are obtained in Jhelum district.

Varieties. Two main types are cultivated in the Province, small seeded or *bajri* and bold seeded or *bajra*. The former is considered superior for human consumption but the latter gives higher yield. *Bajra* is mainly grown under *barani* conditions but where there is enough water supply, bold grained type may be cultivated.

As a result of experiments conducted by the Millet Botanist, following varieties of *bajra* are recommended to the cultivators:—

(1) *A* 1/3.—It has dense ears and the grains are fairly bold, roundish and slate coloured, and are consequently much liked. Its yield is 18-20 *maunds* per acre. The variety does well in Rawalpindi, Gurdaspur, Multan, Jullundur and Lyallpur districts.

(2) *G* 61/21.—It has dense and hairy ears which possess bristles. Greatest advantages in growing this type is that it is very little damaged by birds. Its yield is 15-18 *maunds* per acre. It does well under fair rainfall or good irrigation.

Like *juar* and maize, *bajra* is also cross-pollinated. The method for selecting seed is, therefore, more or less the same as already discussed under *juar*. The chief point in case of *bajra* is that long well filled dense ears should be given preference when selecting for seed.

Uses.

Bajra grain is ground into *ata* and consumed by people of the tracts where it is grown. It may also be used for making a special preparation called *rabari*, *i.e.*, *bajra ata* mixed with butter milk, which may be fresh or stale and cooked in the evening on the fire after adding necessary salts and spices. *Bajra* may also be used in the preparation of *khichri* of *mung*, *moth* or rice, and is very much relished in south-eastern districts and parts of Ferozepore. Small quantities of *bajra* are also consumed in the form of *dalia* and for feeding livestock.

INFERIOR MILLETS

Natural order—*Gramineæ*.

Vernacular name	English name	Botanical name	Average area for the quinquennium ending 1940-41 Acres
1. *Ragi or Mandal*	Finger Millet	*Eleusina coracana*	21,000
2. *Kangani*	Italian Millet	*Setaria Italica*	9,500
3. *Cheena*	Common Millet	*Panicum miliaceum*	30,000
4. *Swank*	Little Millet	*Panicum colonum*	26,000
5. *Kodra*		*Paspalum scrobiculatum*	800

These millets are mainly grown on poor soils. A major portion of the area under these millets is fed to livestock as green fodder. Though used as food by certain number of people of the hilly districts and also by some in the plains, the grains of inferior millets are not considered as wholesome article of diet. The composition of different millets as compared with other food grains, as given in the "Food Grains of India" by A. H. Church is reproduced below :—

Name of food grain	Water %	Albuminoids.%	Starch %	Oil %	Fibre %	Ash %	Nutritive Ratio	Nutrient Value
Cheena	12·0	12·6	69·4	3·6	1.0	1·4	1 : 6	89·0
Swank	12.0	9·6	74·3	0·6	1.5	2·0	1 : 8	85·0
Kangni	10·2	10·8	73·4	2·9	1.5	1·2	1 : 7·4	91·0
Ragi	12·5	5·9	74·6	0·8	3.6	2·6	1 : 13	84·0
Kodra	11·7	7·0	77·2	2·1	0.7	1·3	1 : 11·7	89·0
Jowar	12·5	9·3	72·3	2·0	2.2	1·7	1 : 8·25	86·0
Bajra	11·3	10·4	71·5	3·3	1.5	2·0	1 : 7·6	89·5
Wheat	12·5	13·5	68·4	1·2	2.7	1·7	1 : 5·2	84·6
Barley	12·5	11·5	70·0	1·3	2.6	2·1	1 : 6·3	84·5
Maize	12·5	9·5	70·7	3·6	2.0	1·7	1 : 8·3	88·5

From these figures it will be observed that these millets are not inferior to other food grains as far as their nutrient value is concerned. Even in nutritive ratio these millets excepting *ragi* and *kodra* compare favourably with maize, wheat and barley.

1. *Ragi or Mandal.*

This is principally grown in the hills and some of the sub-montaneous districts. It is an important food grain in Simla and Kangra districts. Apart from Kangra which grows about 8,000 acres, large areas in the plains occur in Multan, Jhang, Muzaffargarh, Sialkot and Karnal districts. It is commonly grown on light, poor or alkaline soils and its cultivation is similar to *jowar*, *bajra* or *cheena*. Only 1/4th to 1/3rd of area is irrigated, the rest is all *barani*. The seed rate is 5 *seers* per acre. It is generally sown broadcast, but when sown in nursery, seedlings are raised in a shady place and transplanted as in the case of rice.

It is sown in nursery from May to July and transplanted in July and August. The crop receives 2 to 3 weedings and is often top-dressed with manure after the first weeding. It suffers from excessive rain. A good year for rice is bad for *mandal*. It is harvested in October-November, and yields about 10 to 12 *maunds* of grain and 30 *maunds* of straw per acre. When grown for green fodder it gives about three cuttings and yields about 150 *maunds* of green fodder per acre.

The grain is eaten by poor classes as a staple food in the hills. It has excellent storing properties being free from insect attacks and not liable to become mouldy. For this reason it has been used for storage against scarcity and famine.

There are two types generally grown—black grained and white grained. White grained type is preferred to the other when grain is to be utilized for human consumption but for obtaining fodder both are equally good.

2. *Kangni.*

It is largely grown in Kangra and Karnal, though small areas are found in Gurdaspur, Montgomery, Rawalpindi and Lahore districts also. It has a wider range as regards season than other millets and is often grown after famines when quick return is required.

The crop is often sown on manured lands near the villages in hill valleys in May-June. The seed rate is 3 to 4 *seers* per acre. *Kangni* is of two types—red and white. Birds are very fond of the seed and do much damage to the ripening crop.

The season for harvesting is September-October, and the yield is about 5 to 6 *maunds* of grain per acre. It is also grown as an early fodder crop. For this purpose it is sown in March and is ready for feeding in May. It gives 100-150 *maunds* of green fodder.

Unlike other inferior millets, its grain is very little used as human food. The grain is generally fed to poultry and cage birds. Whenever taken as human food it is boiled like rice. As an article of food it is sometimes objected to on account of its heating properties and when taken as a sole food it is said to be sometimes apt to produce diarrhœa. When boiled with milk it forms a light and pleasant meal for invalids. Medicinally it is said to act as diuretic and astringent and is sometimes used externally in the case of rheumatism.

Cheena.

This is of little economic importance except as an early fodder or grain crop. For this purpose it is sown in March at the rate of 5 seers per acre and is ready for green fodder in the month of April. The fodder is relished by cattle and horses. For grain the crop is harvested in May and June, and its yield is about 4-6 *maunds* per acre. It is considered to be nutritious and in many places it is eaten after cooking like rice or taken with *lassi*, the preparation being called *bhat*. Round about Simla it is sometimes used in the form of *chapatis*. It is also fed with *kangni* to cage birds.

4. *Swank.*

This is the quickest growing plant of all the millets and is supposed to ripen within six weeks to two months after sowing. It is found wild in most parts of the Province, but large areas under this crop are found in Dera Ghazi Khan, Gurdaspur, Multan, Montgomery, Jhang, Hoshiarpur and Muzaffargarh Districts. Two types of *swank* are recognised by farmers—broad leaved and narrow leaved, but there is not much difference in their seeds. The former grows taller and gives better and more fodder than the latter.

The usual seed rate is about 4-5 seers of grain per acre. It is usually sown broadcast and is often grown for green fodder, or cheap grain in August and September before *bajra* is ready. An ordinary crop yields about 4-6 *maunds* of grain or about 100 to 150 *maunds* of green fodder per acre.

The grain is chiefly consumed by poorer classes of people. Hindus consider it to be a very sacred grain and it is preferred by them for religious offerings. On *Ikadshi* festival it is taken by them in different ways and forms. At *Lohri* festival also, they start and break the fast with this sacred food.

5. *Kodra.* It is not an important crop in this Province. It is only grown in Simla district and that too, to a small extent. The seed rate is about 4 *seers* and is sown broadcast. Its cultivation is similar to that of other inferior millets. There are two types of it—*bali* and *desi*. The former has got light red coloured grains, sweet in taste and the latter possesses dark grey seeds of bitter taste. *Desi* variety grows taller and is cultivated on higher hills, while *bali* varieties are usually grown on comparatively lower altitudes. It is preferred both by zemindars and traders and fetches a premium of about Re. 1 per maund over *desi* varieties.

Importance in new colonization. These inferior millets, particularly *kangni* and to a less extent *cheena*, and *swank* play an important part in breaking up new land or in recovery after famine. When the cultivator with his cattle returns to his homestead after a famine or enters a new area for colonization, he can only carry a limited amount of foodstuffs and fodder with him. He must therefore produce both grain and fodder as quickly as possible in the new area. If his entry is in an irrigated tract in March-April he sows *kangni* or *cheena* if later, *swank*. Generally these millets produce a crop in 60 or 70 days—a very important economic consideration.

6. *Buck Wheat.* (*Fagophyrum esculentum. Pohygonaca.*) This is not a millet as it belongs to a different Natural Order, but it is mentioned here because this grain is used like inferior millets in the hilly areas.

This crop is extensively cultivated in the Himalayas, between 4,000 and 10,000 feet heights. It is a rainy season crop being sown in July and reaped in October. The forms met at lower elevation are stunted and have thick swollen stems of a red shiny colour with pink flowers. It is chiefly grown as a vegetable, the leaves and tender shoots being ed as pot herb. The grain as a human food does not hold high place as it is hard, bitter, and rather unpalatable ıd is said to have a heating effect on the human body. ı the Plains it is sold only by *pansaris* or druggists and not r general grain dealers, and is used by orthodox Hindus as special food on religious occasions, such as fast days.

In England buck wheat is mainly used for feeding ıeasants and poultry.

References

(1) Reports on the Season and Crops of the Punjab.

(2) United States Department of Agriculture—Agrilture Statistics,—1943.

(3) A summary of the more important results arrived or indicated by the Agricultural Stations and Research ficers in the Punjab—1930-31 to 1934-35 and 1935-36 1937-38—Department of Agriculture, Punjab.

(4) Report on the Marketing of Wheat in India—(1936).

(5) Report on the Marketing of Wheat in the Punjab—940).

(6) Reports on the operations of the Department of riculture, Punjab.

(7) Principles of Cereal Storage by F. P. Coyne.

(8) Studies in the Cost of Production of Crops in the Punjab by Prof. Kartar Singh (1934) (Board of Economic Enquiry, Publication No. 33).

(9) Report on the Cost of Production of Crops in the principal sugarcane and cotton tracts in India—Volume I—The Punjab—1938—I.C.A.R.

(10) Report on the Marketing of Barley in the Punjab (Unpublished).

(11) Report on the Marketing of Maize in the Punjab (Unpublished).

(12) Report on the Marketing of *Jowar*, *Bajra* and inferior millets in the Punjab (Unpublished).

(13) Report on the Marketing of Rice in India and Burma—(1941).

(14) Health Bulletin No. 23—The Nutritive Value of Indian Foods and the planning of Satisfactory Diets.—1937.

(15) Department of Agriculture, Punjab's Leaflets Nos. 6, 7, 46, 46-A, 63, 72, 82, 85, 104, 105, 113, 118, 123, 126, 127, 134, 136, 147, 159, 161, 174, 183, 184, 187 and 193.

(16) Foodgrains in India by A. H. Church.

(17) Dictionary of Economics Products by Watt.

(18) Handbook on Field and Garden Crops in the Punjab by Messrs. D. Milne and Ali Mohammad (1931).

(19) Wheat Studies of the Food Research Institute Stanford University, California (U. S. A.).

CHAPTER XII

FOODGRAINS—PULSES

Nat. Order—*Leguminosæ*.

Pulses have been used as an article of diet in India from times immemorial. For the health and wellbeing of the people who are mainly vegetarian, pulses take a very high place in the diet because of their high contents of protein, mineral matter and vitamin B. They may be described as poor man's meat, and are often used in conjunction with other foods rich in starch, *e.g.*, rice or wheat. Pulses are often consumed after being cooked whole or in the form of *dal*, *i.e.*, split pulse with or without husk. The prepared product may be dry or in the form of soup. Different pulses may be cooked separately or mixed together to make a more balanced and palatable dish. Mixture of pulses of *mash* and gram, *mash* and *mung*, and *massar* and *mung* are quite common. *Dals* are also commonly cooked with rice which is known as *khichri* and which is considered to be light and good for invalids. Usually *mung* is preferred for this purpose. *Moth* and *bajra* are also quite commonly used to make *khichri* in the South-Eastern tracts. Special preparations such as *papars*, *varis*, *pinnis*, etc. are also prepared from the various pulses. The nutritive values of important pulses are shown in the following table :—

	**Mash*	**Mung*	†*Moth.*	**Massar*	**Arhar*	†*Gram*
Moisture per cent ..	10.9	10.4	11.2	12.4	15.2	10.8
Protein per cent. ..	24.0	24.0	23.8	25.1	22.3	19.3
Fat (Ether extraction per cent.)	1.4	1.3	0.6	0.7	1.7	4.6
Mineral matter ..	3.4	3.6	3.6	2.1	36	3.1
Fibre per cent. ..	..	4.1	4.2	..	..	62.2
Carbohydrate per cent. ..	60.3	56.6	56.6	59.7	57.2	..
Calcium per cent. ..	0.20	0.14	..	0.13	0.14	..
Phosphorus per cent. ..	3.37	0.28	0.8	0.25	0.26	..
Iron per cent. ..	9.8	8.4	..	2.0	8.8	..
Calorific value per 100 grains	350.0	334.0	..	346.0	333.0	..
Carotene (International units vitamin A per 100 gms.)	64.0	158.0	..	450.0	220.0	..
Vitamin B_1 International units per 100 gms.)	40.0	150.0	..	150.0	160.0	..
Vitamin B_2 ..	+ +	+ +	..	+	+ +	..
Vitamin C. Mgs. per 100 gms.	..	..	..	..	..	..
Remarks ..	With outer husk	without *outer* husk			without outer husk	

**Health Bulletin No. 23.* †*Dictionary of Economics products, Watt.*

It would be observed that *mash dal* is the richest in phosphorus and iron contents and contains fair amounts of Vitamin B_1 and B_2. It is, however, difficult to digest and causes flatulence unless eaten with asafoetida. *Mung dal* contains comparatively large amount of fibre but it is richest of all *dals* in Vitamin B_1. It also contains fair amounts of Vitamins A and B_2. It is a *dal* which is easily digested and agrees even with the weakest constitution. It is usually prescribed by doctors as well as *hakims* for invalids, etc. *Massar dal* is richest in Vitamin A. It is supposed to have a heating effect on the human system. It is, however, considered to be useful in cases of constipation and other intestinal affections.

The area and production of various pulses in the Punjab are shown below :—

	Area (Acres)	*Production* (Tons)
Mung	248,000	32,200
Mash	216,000	32,000
Other *kharif* pulses mostly *moth* ..	325,000	48,000
Massar	215,000	40,000
Gram	3,600,000	757,000

These pulses will now be discussed separately.

MUNG

Natural Order—*Legunminosæ.*

Botanical Name—*Phaseolus mungo.*

Vernacular Name—*Mung.*

Mung is largely a *barani* crop; only 20 per cent area being irrigated and 80 per cent unirrigated. Most important districts where this crop is extensively grown are Rawalpindi, Hissar, Jhelum, Ferozepur, Attock, Multan, Montgomery and Ludhiana. It is commonly sown as a subordinate crop with maize, *juar* and sometimes *bajra*. It does best on medium loamy soils. It is more drought resistant than *mash* but cannot stand as dry conditions as *moth*. *Mung* is sown from the middle of June to end of July depending upon the monsoon. The preparatory tillage is the same as that for *juar*, maize and *bajra*. When grown alone, the preparatory tillage is meagre. Two ploughings are considered to be quite sufficient. The seed rate when sown alone is about 5 *seers* but when sown with *juar* or *bajra* 3 to 4 seers is considered to be sufficient. The crop is ready for harvest from end of September to the middle of November. On the basis of time of ripening two varieties are recognized by the farmers—one *Bhadwari mung* and the other *Katki mung*, the former being ready for harvest in September and the latter in October-November. These varieties cannot be recognised from their grains. Their early and late characters are known only to the farmers who grow them. The earlier types are believed to produce poor quality of grains containing a greater percentage of hard seeds which do not soften on cooking. Late varieties are known to yield superior quality of grain. They also yield more foliage. On the basis of colour three types are recognized by trade—green, black and yellow. Green-seeded type is, by far, the most common and is sown throughout the province. The cultivation of the other two varieties is restricted to special tracts such as Sialkot and Gurdaspur and in south-western parts of the province, *e.g.*, Dera Ghazi Khan and Muzaffargarh districts. Yellow and black *mung* are inferior to green *mung* in yield as well as in edible qualities. Therefore, they have not assumed much importance in trade. An extra bold variety of dull green colour known as *cheena mung* is also sometimes sold in the *bazar* but this is imported from outside the province and not produced locally.

On an average three men are required to harvest an acre of crop. After collecting on the threshing floor the crop is threshed by means of bullocks. Three bullocks and two men can finish the job in a day. The winnowing is done by means of a *chhaj*. An average crop of *mung* may yield 6 to 8 *maunds* grain and 12 to 15 *maunds* of *bhusa*. The *bhusa* is valued for feeding cattle, especially in the rainy season. In the official estimates, however, yield of *mung* is shown to be only 3½ *maunds* per acre for the year 1944-45. Heavy or untimely rains, especially a flowering time, damage the crop considerably. At thi time even damp winds blowing from the East *i.e.*, *Pure* interefere with the fertilization of flowers and reduce the yield considerably.

MASH

Natural Order—*Leguminosæ.*

Botanical Name—*Phaseolus radiatus.*

Vernacular Name—*Mash.*

Of the total area under *mash*, nearly 33 per cent is irrigated and the rest is sown *barani*. The most important Districts for *mash* are Gurdaspur, Kangra, Montgomery, Ambala, Multan and Ferozepur. The cultivation of this crop is similar to that of *mung*. It is, however, mostly grown as subordinate crop with maize and requires stiff loamy soil and a good water supply. It is sown at the end of June or early July with the outbreak of monsoons. When sown alone, only a meagre preparatory tillage is required. No interculture or weeding is generally done, as is clear from the following Punjabi proverb :—

> *Jat ki jane rah—chhola ki jane wah—Mahn ki jane ghah, i.e.*, the farmer does not care for a regular path, whilst gram can do well without any preparatory tillage and *mash* does not mind the weeds.

The crop is generally ready by the end of September to beginning of November, and 6 to 8 maunds of gram and 20 maunds of *bhusa* can be obtained from an average crop. In the official forecast the yield is shown only 4 maunds for the year 1944-45. It appears to be rather underestimated.

Generally two types are recognised both by zamindars and by traders—green *mash* and black *mash*. Unlike *mung*, black seeded type is by far the most common, and is considered to be superior in edible qualities to green *mash*. Black *mash* is grown in submontane districts of the province *e.g.*, Gurdaspur and Kangra, whilst green type is commonly grown in drier parts of the South-Western Punjab

, Multan. Generally speaking, green *mash* ripens ear- than black-seeded type. The grains of the black *mash* also usually bolder than those of the green *mash* ugh this is not always strictly true. *Mash* grown in mid regions and at higher altitudes is of better cooking ality than that grown in the plains. *Mash* varieties wn in Kulu, Simla and parts of Gurdaspur and Sialkot trict are considered to be the best of all types of *mash* nd in the Province. *Mash* from the hills have got property of cooking easily. Apart from the locally grown pes, a special type of *mash* known as *Kurrum mash* th extra bold grains is found in the markets. This is ported from Kurrum Valley, in the N.W.F.P., and sold the *bazar*.

MOTH

Natural Order—*Leguminosæ*.

Botanical Name—*Phaseolus aconitifolius*.

Vernacular Name—*Moth*.

The area under *moth* separately is not available. It is, however, the most important pulse included in the "other *kharif* pulses", for which area is available in the Season and Crops Report, Punjab. It is mostly grown under dry conditions and is an important crop in the Districts of Gujrat, Ferozepur, Hissar, Ludhiana, Rawalpindi, Attock and Jhelum. The total area is estimated to be about 3 lakh acres. The crop is, however, frequently grown for fodder mixed with *juar* or *bajra*. In the canal or irrigated tracts, it is often grown mixed with early fodders and also with cotton. In the latter case it is removed in August, and used as green fodder. Only a small part of the total crop is grown for seed purposes. It is generally grown on light sandy soils under *barani* conditions, and is the most drought resistant of the three pulses discussed above. Its cultivation is similar to that of the other pulses. The seed rate is about 8 *seers* when sown alone and 4 to 6 *seers* when mixed with other crops. The sowing time is from middle of June to end of July and harvesting time from the beginning of October to first half of November. The average crop yields about 5-6 maunds of grain and about 10 to 12 maunds of *bhusa*. Two main types are recognized in the trade: (1) black *moth* (also known as *kali mungi* in Gujrat) and (2) *gora* or whitish green moth. The latter type is commoner of the two. Black type is grown to a lesser extent, mostly in Gurgaon and Gujrat districts. For culinary purposes *moth* is regarded as inferior to *mung* and *mash* for human beings. Dislike of a person is sometimes expressed thus : He is like *moth* in your *dal*.

LENTIL

Natural Order—*Leguminosæ*.

Botanical name—*Lens esculenta*.

Vernacular Name—*Massar*.

This pulse is grown to a limited extent all over the province. The most important districts, however, are Sialkot and Gurdaspur. The other districts of lesser importance are Montgomery, Ambala and Karnal. It is mostly grown on *sailaba* lands, and generally the first crop sown on new alluvial soils recovered from the rivers. It is generally sown alone, but is sometimes sown mixed with barley in Hoshiarpur district. It is rarely sown on land which has been fallow the previous *kharif*, and hence it is a suitable crop to follow *juar*, rice, etc.

The cultivation given is meagre, and consists of one or two ploughings only. It is sown broadcast at the rate of 12 to 16 *seers* per acre.

Sowing time is October-November along with other *rabi* crops. It can, however, be sown very late, even upto January. The average yield is about 6 maunds grain and 12 maunds *bhusa*. It is subject to the same diseases and pests as gram. The young green pod, as in the case of gram, is used as a vegetable.

There are two types recognised by the trade. The bold seeded types are known as *massar* while the small grain varieties are denominated as *masri*. On the basis of colour these types can be further divided into two sub-types; red coloured and dark reddish coloured. The bold grain variety of the red coloured type is quite popular in the province. It is known as *malka massar*, and is mostly produced in the Dera Ghazi Khan district.

PIGEON PEA

Natural Order—*Leguminosæ.*

Botanical Name—*Cajanus indicus.*

Vernacular Name—*Arhar.*

Arhar is an important pulse crop in India but it is not cultivated to any great extent in this province, the total area being only 3 to 4 thousand acres. Of this nearly 4/5th is grown in Gurgaon, 1/12th in Kangra district, and the rest in the districts of Multan, Jhang, Gurdaspur, Montgomery and Hissar.

Arhar is grown mostly as a subordinate crop along with *juar*, *bajra* but it is also, though to a very small extent, grown by itself. When cultivated as a mixed crop, the soil on which it is grown is the same as that for *juar*, *bajra* and cotton, but when sown alone it prefers moist sandy loams. In the Punjab it may be met with as a border crop sown around sugarcane and cotton. In the latter case it protects the crop considerably from hot and dessicating winds.

About 6 *seers* of seed are required per acre if sown singly, but when sown with other crops, 2 *seers* of seed is sufficient. The seed may be sown by broadcast or by *kera*, *i.e.*, by dropping seeds behind the plough. Sowing of *arhar* is usually done with the commencement of monsoon rains. It receives the same operations as the other crops with which it is sown. According to the time of maturity, there are two varieties—an early variety which ripens in November-December and the late variety which ripens in March-April. The late variety is liable to be adversely affected by frost. A single cold night may utterly ruin the crop. The crop when ready is cut and stacked on the threshing floor. The leaves and pods are first of all stripped off the stems and heaped together and then the grain is threshed out either by bullock treading or by beating it out with a stick.

The average outturn when grown alone is about 7 maunds of grain and 16 *maunds* of *bhusa* per acre. When grown along with other crops the yield may be 1 to 5 *maunds* depending upon the intensity of sowing.

On the basis of colour of the grain, two varieties are recognized in the trade—*sufaid arhar* and red *arhar*. The latter type is the commoner of the two in the Punjab, and comprises the bulk of the crop in the Gurgaon district. This pulse is not liked so much by the Punjabis—It is, however, highly esteemed by people in other parts of India.

SOYA BEAN

Natural Order—*Leguminosæ*.

Botanical Name—*Glgcine hispida*.

Soya Bean is a native of Eastern China. China, Korea, Manchuria, Mongolia and Japan are its ancient homes, but the cultivation of this bean has now been extended to almost all other countries. It is said that long before the dawn of civilisation primitive man subsisted on wild soya bean. Soya bean has been for over 7,000 years the chief article of diet in China where 13 million acres are annually grown under it. There are 1,400 varieties. The U.S.A. began to explore the possibilities of growing soya bean in 1920. In 1930 the area was 4½ million acres and rose to 9 million acres in 1944. This indicates the rapid progress made by U.S.A in the cultivation of soya bean. It thus appears that there is a need for more thorough research in India on this crop. It is both a legume and an oilseed and is the foundation crop in the agriculture of China and Korea.

Cultivation. It grows in nearly all types of soils but the best results are obtained in sandy and loam soils. The crop is suited to warm temperatures or temperate zones. Very severe winter and excessive heat are detrimental to its growth. The best time for planting is the rainy season. It should be planted with the break of monsoon. It is sown in rows 2 to 3 feet apart according to the fertility of the soil. The distance between the plants may be 3 to 4 inches. The seed rate per acre is 16 to 20 pounds when grown for seed. For green manuring or fodder purposes seed rate may be double this amount. Too deep planting is not good for seed crop. The depth should not exceed 2 inches. Usually one inch depth gives the maximum germination results. Farmyard manure at the rate of about 12 cartloads per acre may be applied to get good yields. The crop matures within 90 days. During the early stage of growth thorough interculture should be given so as to keep down the weeds. In India average yield of about 800 pounds per acre is considered fairly good, though in Manchuria yields upto double this amount are commonly obtained. It has been tried in the Punjab very successfully on experimental farms of the Agricultural Department. A yield of about 12 to 16 *maunds* of grain per acre has been obtained. Two varieties namely "Chocolate" and "Yellow" have been successfully cultivated. Unfortunately there is no market for the crop. Those, who grew it, were compelled to feed the produce to the cattle. There is a good scope for the introduction of this crop if a market can be found for the sale of the produce at reasonable rates.

The table below gives the composition of soya bean and some other legumes and wheat:—

Legume	Protein	Fat	Nitrogen free extract	Fibre	Ash
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Soya Bean ..	36.5	17.5	26.5	4.3	5.3
Field Pea ..	22.9	1.1	57.8	5.6	3.4
Cow pea ..	23.6	1.5	53.8	4.1	3.4
Garden pea ..	25.6	1.6	53.6	4.4	3.0
Gram ..	19.0	4.3	54.0	..	2.8
Mash ..	23.96	1.26	56.69	4.1	3.67
Wheat ..	12.0	1.7	73.7	..	1.5

The percentage of moisture has not been included in the above figures.

It will be observed that the composition of soya bean differs widely from other legumes. The chief difference lies in the amount of proteins, oil content, the nitrogen free extract and mineral matter. The fat and proteins are found in much larger quantities than in other legume seeds, while nitrogen free extract is very much less than in other legumes. The difference lies not only in the quantity, but also in the quality of its nutrients. It has been seen that the proteins of soya bean are alkalising in their effect, while the proteins from meat and fish, as well as. from eggs and grain are acid producing. This fact makes soya bean a desirable substitute as human food.

Further the soya bean is free from nucleo proteins, and, therefore, it does not form uric acid and in consequence does not encourage gout. Gout is unknown in China, which is the home of soya bean. It contains sufficient amount of fat soluble vitamins A and D and water soluble vitamins B. Dark and brown seeded varieties have practically no starch, while yellow seeded variety shows a little trace of starch. The soya bean is, therefore, an excellent food for those suffering from diabetes. Soya bean is also rich in lime.

The soya bean has got many industrial uses. A very large number of Indian and European dishes can be prepared from soya bean. A large number of recipes for preparing different types of dishes are given in the book Soya Bean by F. S. Kale.

GRAM

Natural order—*Leguminosæ*

Botanical name—*Cicer Arietinum.*

Vernacular name—*Chana.*

Gram is a leguminous *rabi* crop. It is probably indigenous to South-eastern Europe or South-western Asia. Its cultivation in India is ancient, as its Sanskrit name *chana* indicates. The Romans called it "Cicer". It is called *Arietinum* from the resemblance of the seed to the head of a ram.

Gram is an important crop in India in the upper basins of the Ganges and the Indus. The tracts north of a line from Bombay to Patna constitutes the gram producing areas, its chief centre being the province of Agra. In the Punjab gram is mainly grown in the Districts of Hissar, Ferozepur, Rohtak, Mianwali, Karnal, Gurgaon and Shahpur named in order of their importance. In other words the south-eastern areas principally and small block of area in the western corner of the province are the chief concentrated areas of production.

Distribution.

The total gram area in India is about 15 million acres. Of this, the area grown in the Punjab on the average of 4 years ending 1943-44 is about 4 million acres. But fluctuations from year to year are considerable; in some years the total area may be even less than 3 and in others it may go over 6 million acres. The variations are particularly pronounced in the case of *barani* crop which forms nearly 76 per cent. of the total area under gram. This is but natural as the *barani* sowings are dependent upon rainfall. If timely rains are received, the area sown is high, but if rains fail the area sown is very low. Before 1921-22 the area under gram was usually under 4 million acres, but since then, barring the effect of the climatic conditions at the sowing time, the area has gone up by about 1 million acres. The increase has taken place both in irrigated, as well as unirrigated areas, but the former, which has almost doubled itself due to new canals, is the most important. In recent years the increase in area under gram has also taken place at the expense of barley.

Area.

The crop, as generally grown by zemindars, consists of a number of varieties. Of these 5 types only are generally recognized, *viz.*, the small and large *Kabuli* and the black, brown and yellow seeded common variety. *Kabuli* gram is also known as white gram. Its seed coat is cream coloured. The area under *Kabuli* types is negligible and comparatively small quantities enter into trade channels. The dark coloured varieties are most commonly met with in the western Punjab, whilst yellow variety is mostly cultivated in the Ferozepur district and Faridkot State (Kot Kapura).

Varieties.

Out of the local varieties the Punjab Agricultural Department has isolated various types. Some of them yield more than the usual mixture grown. The characteristic of a few promising types are given below :—

Type No. 1.—It is a *Kabuli* type. Its grain is bold almost equal to 3 grains of ordinary gram and cream coloured. It is mostly used for culinary purposes and commands a much higher price per *maund* than the ordinary type. Unfortunately, its yield per acre is low if the ordinary seed rate of 16 *seers* is used. But with 40 *seers* seed rate it compares quite favourably with the Department best selection type 7.

Type No. 7.—This type has an attractive brownish yellow grain and possesses vigorous habit of growth. It does very well in many parts of the province.

Type 17.—This type possesses dusky brown grains. It has more grains per pod than many other varieties. Its yield is nearly as good as that of type No. 7 in favourable circumstances, but it sells at a slightly lower prices.

In the Sargodha colony type No. 15, a yellow coloured type, has fared very well. A new type which bears two fruits on one peduncle instead of the usual one fruit has also been evolved and is under trial.

Since all Punjab types of gram are highly susceptible to gram-blight, attention is now being concentrated on certain imported types. Of these types, 3 French varieties have been found to be resistent to this disease. These are F. 8, F. 9 and F. 10 of which F. 8 is at present the best, but it is highly susceptible to gram wilt. Its yield is also low. Further breeding work is in progress with a view to evolving a variety which is resistant to blight and is also a high yielder. So far the variety 12/34 seems to be promising.

Soil.

Gram is sown on all soils from the heaviest clay loams to the lightest sandy loam; but it is on the former class of soil that it yields best provided it is not too damp. This crop grows better than any other crop on the lightest soils of the Province. Since gram is a leguminous crop it tends to improve soil by adding nitrogen. If a gram plant is pulled up carefully the large wart like growth on the roots—sometimes larger than eight-anna piece, can be plainly seen. These are formed by nitrogen fixing bacteria.

Season.

Gram is the earliest sown of the *rabi* crops, sowings beginning as early as September. By the end of October the sowings are almost finished. Within these limits the time of sowing is determined by the occurrence of rainfall. The harvesting starts a fortnight or three weeks before wheat. In the eastern Punjab the seeding and harvesting begin about a fortnight earlier as compared with the northern and western districts.

Seed rate.

The seed rate in the Punjab is generally from 12 to 16 seers as compared with 40 or 50 seers in the Central Provinces. In the case of bold-seeded varieties, however, a high seed rate should be used, for otherwise the stand of the crop is likely to be poor and yield low.

Cultivation.

Gram is generally sown on lands which lie fallow in the *kharif*, but it is also often grown after early fodder crops such as *chari*, maize and *guara*. The seed bed is generally roughly prepared, but a deep tilth is favourable, though the soil need not be pulverized as in the case of wheat. In the *sailaba* lands it is often sown broadcast without any previous cultivation and merely covered by ploughing once or twice.

Gram is generally sown by the *pora* system. It is often sown mixed with wheat, barley, linseed, *taramira*, *sarson* or peas. Should rains be favourable, wheat or barley, etc. gives a good yield whereas gram subsist best when rainfall is low. In the irrigated lands one or two waterings after sowing may be given, but the preservation of a loose open soil is important for this crop and harrowing in early stages of growth is beneficial. Since gram is a deep-rooted crop the application of irrigation during the early stages of growth is injurious. The crop is rarely weeded. Sheep and goats are sometimes allowed to nip off the top shoots just before flowering in cases of luxuriant growth in order to encourage branching.

Harvesting.

The gram crop is harvested just before it is dead ripe and the harvesting is usually done by means of hand sickle. Ordinarily three to four men can harvest an acre of average crop in a day.

In some places the uprooting of the whole plant is also resorted to. The cut crop is taken to threshing floor without tying into bundles, where it is fully dried before threshing which is usually accomplished by *mehr* system. The bullocks are driven round and round over the crop in order to thresh out the grains and break the plants into pieces. Three bullocks and two men can deal with an acre of irrigated or two acres of unirrigated crop in a day. In some districts *e.g.*, Ludhiana and Ferozepore, the dry crop is shaken and the stems of the plant are separated from the grain bearing pods by means of *trangli*. The grains are then extracted out of pods by means of treading by bullocks. Small lots of crop may be threshed with a stick. Winnowing is done by means of *chhaj*. This operation, like others, is chiefly done by the farmer and his family, but when hired labour is employed, it is paid at the rate of 1¼ to 2 *seers* per *maund* of gram winnowed.

Pests and diseases.

Gram is damaged by white ants to some extent and suffers also from a caterpillar known as *sundi* or *bahaduri*. Frost does considerable damage in some years, mostly at the end of January and early February. But the most dangerous enemy of this crop is "gram-blight." Almost complete destruction may result in cases of serious attack. In the Attock and adjoining districts of Rawalpindi, Jhelum and Mianwali gram crop has been a complete failure for a number of years on account of this disease. Recently this disease has also been observed in Gujrat, Lyallpur and Gurdaspur Districts but the damage done has not been serious, probably, due to climatic conditions. This disease is caused by a fungus which affects all parts of the plant above ground. Concentric brown spots varying in size appear all over the surface of plants. These spots are especially prominent on the pods. The various parts of plants above ground wilt and become withered. As a result of experiments it has been found that the soil does not harbour the disease; it is carried by the seed. Since the disease is produced by sowing infected seed, it is necessary to use disease-free seed imported from places where the disease does not occur. Secondary, infection also brings about a large percentage of disease. For this reason, it is essential to carry out other control measures as well, on an extensive scale. The debris of the diseased plant which carries the disease from one season to another should either be collected and burnt or buried in the soil with a furrow turning plough. Throwing the debris on the manure heap also helps in the destruction of the disease. Besides, this mixed cropping should also be encouraged, since incidence of the disease is diminished when gram is sown mixed with wheat or barley. The best remedy is to grow the disease-resistant varieties mentioned before.

Gram wilt is also a serious disease of this crop in the central as well as south-eastern Punjab. The best remedy in this case also is to grow a disease-resistant variety. Type No. 7 is fairly resistant to this disease but work has recently been started at the Ferozepore farm to evolve a still better wilt-resistant variety.

Storage.

The methods of storing gram are similar to those of wheat which have already been described. The produce is stored either in bags or in bulk. The former method is usually followed in deficit or importing areas and the latter in surplus areas, especially, in south-east. When stored in bulk a layer of *bhusa* is spread at the bottom of the floor and another layer at the top. In the Hissar District sand to an extent of 50 to 60 per cent of the weight of gram is mixed and it is claimed that damage is considerably reduced. At some places tobacco and *taramira* dust is also used at times. In Leiah gram stored in dark rooms with about 5 per cent dust is said to stand storage better.

The cost of storage on the producer's holding is practically nil as no cash or kind payment is made. But in markets the cost works out to about Re. 1 per 100 bags per month when stored in bags and about 1 *pie* per *maund* per month when stored in bulk in godowns or *kothas*.

Yield.

The yield of gram ranges from 5 to 20 maunds or even more per acre, depending upon the amount of rainfall, soil conditions, cultural practices, attack of disease, etc.

The average yield for the whole province may be taken to be about 6 *maunds* the average for the irrigated and unirrigated areas being 8 and 5 *maunds* respectively.

Total production and utilization.

Since area and yield of gram are liable to considerable variation from year to year, one year's figures cannot possibly give an accurate idea of the volume of the Punjab crop. The average of the 5-year period may be taken to present a better idea than the annual production. During the five-year period ending 1943-44, the average annual production was about ¾ million tons, *i.e.*, about 1/5th of wheat.

It is estimated that in areas of surplus production about 50 per cent. of the total production is retained in the villages and in areas of smaller production 60 to 70 per cent. and sometimes even 85 to 90 per cent. of the crop is retained. Soon after harvest the produce is rushed to the market and by the middle of June nearly 80 per cent of the saleable produce finds its way into the market.

Taken as a whole, the Punjab is an area of surplus production. It exports gram and its products to U.P., Madras, Sind, N.W.F.P., Delhi, Bombay, Mysore, Baluchistan, C.P., Jammu and Kashmir, Bengal, and many other places of minor importance. From the neighbouring states particucularly from Patiala and Faridkot a small amount is also imported. During the year 1935-36 the net export of gram and its products (*dal, basin* and crushed gram, husk) was about 3,081,762 *maunds* or 113,217 tons. The total production in 1934-35 was 798,300 tons. Thus the net available supply for consumption in 1935-36 was 685,083 tons.

Dal is the most important of the gram products from the point of view of export. A large share of the total exports originates from Hissar and Ferozpore districts, and the lion's share of these exports goes to the Madras and Bombay Presidencies.

Gram is used in the Punjab mainly for human consumption, stock feeding and sowing the next crop. During the year 1935-36 the net available supply utilised under these heads was as follows :—

		Maunds
(*i*) Seed	..	1,647,768
(*ii*) Human consumption	..	8,500,098
(*iii*) Stock feeding	..	8,500,098

For human consumption gram is mainly used in the form of meal mixed with wheat flour (*missi roti*) pulse, and parched grains. An appreciable amount, though small in comparison with the above three uses, is used in various other ways as well. For instance, *basin* is utilised in the preparation of numerous sweetmeats, *pakauras*, etc. *Kabuli* gram is used for culinary purposes. Cooked *Kabuli* gram, fried grains and *dal*, etc. are sold as such in towns and cities.

Gram is a very favourite stuff for the feeding of livestock in the Punjab and is an excellent concentrated food. Gram meal and husk are fed to milch cattle. Crushed gram is the staple concentrate fed to bullocks, horses and mules. For this reason Military Department purchase large quantities in the Punjab.

The price of gram on the whole moves along with that of wheat. Usually it is less by about 20 per cent. but in some years gram prices have equalled, and even exceeded, those of wheat. This is due to low production of gram in relation to its demand and also because the price of wheat is governed by the world market, whereas that of gram only by local demand and supply.

Among the other uses of gram, it may also be mentioned, that the green shoots and pods are eaten raw or cooked, to a large extent, in several areas. The chaff or *missa bhusa* is also relished by stock. It is highly valued in the south-eastern tracts where it is carefully prepared. But in other places it is not considered to be of much use and is fed mostly to donkeys.

Cost of cultivation and income.

An estimate of the cost of cultivation of gram in the *barani* areas of the Punjab is given below:—

	Rs.	a.
Ploughing 1@ Rs. 1-8	1	8
Seed 15 srs. @ Rs. 3 per *maund* ..	1	2
Sowing	1	0
Reaping 3 men	1	8
Threshing (3 bullocks and 2 men can thresh two acres of *barani* crop in a day)	1	4
Winnowing 2 seers per *maund* 10 *seers*	0	12
Land revenue	1	8
Net rent	6	0
	14	10
Income—		
5 *maunds* grain @ Rs. 3 per *maund* ..	15	0
6 *maunds bhusa* @ Re. 0-8-0 per *maund*	3	0
	18	0
Net profit ..	3	6

In the irrigated areas the cost of production will be about Rs. 25 per acre and the net profit will amount to about Rs. 5 per acre.

References.

(1) Health Bulletin No. 23—The Nutritive Value of Indian Foods and the Planning of Satisfactory Diets—1937.

(2) Dictionary of Economics Products by Watt.

(3) Report on the Marketing of Pulses in the Punjab (Unpublished).

(4) Season and Crops Reports of the Punjab.

(5) Report on the Marketing of Gram in the Punjab (Unpublished).

(6) A summary of the more important results arrived at or indicated by the Agricultural Stations and Research Officers in the Punjab—1930-31 to 1934-35 and 1935-36 to 1937-38—Department of Agriculture, Punjab.

(7) Department of Agrieulture, Punjab's Leaflets Nos. 34, 136, 146, 159, 174, 187 and 193.

(8) Soya Bean by F. S. Kale.

CHAPTER XIII

OTHER FOOD CROPS

SUGARCANE

Natural Order—*Gramineæ.*

Botanical Name—*Saccharum Officinarum.*

Vernacular Nome—*Ganna*, *Kamad*, *Ikh.*

Roughly 63 per cent of the world's sugar is produced from cane and 37 from sugar-beet. India, Cuba and Java are the most important sugarcane producers, while Germany, U.S.A. and Russia are the chief sugar-beet producers. India occupies the first position in the world in cane production.

Area. India grows annually four million acres, of which the Punjab share is about half a million, though in 1944-45 the area had gone a little over 6 *lakh* acres. Although it comes second in India as regards area (U.P. being first) the yield per acre in the Punjab is low, being 8½ tons on irrigated land and 5 tons on *barani* land, as compared to 15 tons in the U.P. and 25 to 28 tons in Bombay and Madras. Though the area of cane represents only 1½ per cent of the cropped area of the Punjab, the crop is important because it gives a high return per acre and requires far more labour, manure and water than most other crops.

The district of Gurdaspur followed by Lyallpur, Sialkot, Jullundur and Rohtak claim 40 per cent of the cane-area of the province. If we take in Karnal, Amritsar, Hoshiarpur, Gujranwala and Ambala, we account for another 30 per cent or, say 70 per cent of the area from these ten districts. The irrigated area comprises 83 per cent and the unirrigated 17 per cent. The latter is mostly grown in Ambala, Gurdaspur and Hoshiarpur—all possessing a rainfall of over 30 inches.

Yield per acre. The yield per acre of cane for all India is 15 tons as compared to 21½ tons in South Africa, 27½ tons in Japan and Formosa, 31½ tons in Egypt, 54 tons in Java and 62 tons in Hawaii. The maximum yield so far obtained in the Punjab is 63 tons of cane with 7 tons of *gur* at the Lyallpur Sugarcane Research Station (Risalewala), in 1940-41 from $\frac{1}{40}$th acre as against an average yield of only 1 ton of *gur* for the Punjab, *i.e.*, 1/7 of the record yield. This shows the vast scope for improvement.

Production.
(a) *Gur.*

The quinquennium ending 1943-44 produced an average of 442,000 tons of gur from 484,000 acres under cane. In calculating the yield of *gur* the area recorded by the revenue officials is multiplied by the average yield. All cane is not, however, converted into gur as the following table shows:—

		Per cent
(1)	Harvesting wages, village functionaries and manufacturers of *gur* ..	2
(2)	For chewing and juice ..	8
(3)	For feeding to cattle ..	12
(4)	Used for seed	5
(5)	Made into sugar	3
(6)	Converted into *gur*	70

Thus only 70 per cent is converted into *gur* and 3 per cent only into sugar.

(b) Sugar.

This is prepared in three ways in the Punjab, *viz.*, by *khanchis*, open pan and vacuum pan factories. In 1936-37 the vacuum pan factories produced 16,631 tons as compared to 196 tons by *khanchis* and 110 tons by centrifugals. There are only two vacuum pan factories in British Punjab, *viz.*, at Rahwali and Abdullapur (Jagadhari). The other two are in Kapurthala State at Hamira and Phagwara. The production of *khanchi* sugar is confined to Jullundur and Ludhiana, while open pans are worked in Hissar, Rohtak, Jullundur, Hoshiarpur, Ludhiana and Ambala.

Trade.

On the average of two years 1937-38 and 1938-39 over 134,000 tons of *gur* and molasses were imported annually, of which 80 per cent came from the U.P. Exports were under 6,000 tons annually in the same period.

In the same period the Punjab Trade Block area imported 176,800 tons of sugar—again mostly from the U.P. Exports amounted to 3,600 tons only.

Utilization.

Supply and demand positions of *gur* and sugar in British Punjab are given below :—

Supply	*Tons*	*Demand*	*Tons*
(*i*) *Gur*—Production 1936-37	325,900	Human consumption ..	356,449
Share of net imports (1937-38) ..	89,123	Cattle feeding ..	58,570
		Distilleries ..	4
Total..	415,023	Total..	415,023
(*ii*) Sugar—Production (1936-37) ..	16,631	By commercial concerns—	
Share of net imports ..	137,264	Syrups ..	7,339
		Desi *murabbas* ..	3,669
		Confectionery ..	734
Total..	153,895	Fruit products, like jams, jellies, etc. ..	330
Less net exports in the form of *murabbas*, etc.	257	Domestic consumption ..	138,630
		Balance as increase in stock ..	2,936
Total .	153,638	Total..	153,638

Per capita consumption in the Punjab (in lbs.) :—

Year	*Gur*	*Sugar*	*Total*
1935-36 ..	29·3	15·2	44·5
1936-37 ..	30·9	18·1	49·0
1937-38 ..	36·4	13·2	49·6

Varieties.

Three main classes of cane are grown, *viz.* (1) *ponda* (for chewing), (2) *desi*, consisting mostly of *katha*, *kahu*, *dhaulu*, *suretha* and *lalri*, (3) Improved Coimbatore varieties. Prior to 1918, only the first two classes were grown. The Coimbatore varieties soon showed their superiority and in 1943-44 occupied at least 4·5 *lakh* acres or 82 per cent of the cane area. *Desi* varieties except *katha* have practically ceased to be cultivated. *Ponda* occupies about 3 per cent of the cane area. Coimbatore canes give about 80 per cent greater yield than *desi* varieties. The most important are Co. No. 285, Co. 396, Co. 313, Co. 312 and Co. 421 in order of importance. More recent promising varieties are Co.

L.5 (late) and Co. L.9 (early). Comparative yields of some of these at Lyallpur are given below :—

1. Early Varieties

Variety	Average for 1940-41 to 1943-44 Cane Mds.	Average for 1940-41 to 1943-44 Gur Mds.	Average for 1944-45 Cane Mds.	Average for 1944-45 Gur Mds.
Co. 313	916	106	853	95
Co. 396	802	92	..	..
Co. L.4	983	109	1,102	122
Co. L.9	1,112	126	1,071	12[illegible]
Co. L.13	..	..	942	123

2. Late Varieties.

Variety	Average for 1941-42 to 1943-44 Cane Mds.	Average for 1941-42 to 1943-44 Gur Mds.
Co. 312	1,395	144
Co. 421	1,211	135
Co. 285	1,078	117
Co. L.5	1,314	148

Among the early varieties Co. 313 has so far been issued extensively to cultivators. It is obvious from the trials that L.4 and L.9 show great promise.

Among the late varieties Co. 312 and Co. 421 are popular with cultivators but L.5 has recently shown good promise.

The results of similar trials at Jullundur for 1943-44 are as follows :—

1. Early Varieties

Yield per acre in *maunds*.

Variety	Cane	*Gur*
Co. 313	1,054·12	97·12
Co. L.4	1,080·37	92·60
Co. L.9	1,023·37	94·87

1. Late Varieties.

Yield per acre in *maunds*.

Variety.			Cane.	*Gur*.
Co. 312	..	..	1,075·40	83·00
Co. 421	..	..	1,013·50	84·00
Co. 453	..	..	1,157·00	108·00
Co. L.5	..	..	1,001·50	83·90

Here Co. 453 in late varieties is more promising than Co. L.5.

There used to be prejudice against Coimbatore canes in that they are late in ripening and if crushed or used for chewing at the same time as the *desi* varieties, give poor *gur*, or produce ill effects. Co. 313, however, and some others ripen early in fact as early as *desi katha*. The early ripeners are Co. 313, Co. L.4 and Co. L.9, medium ripeners, Co. 285 and Co. 313 and late ripeners Co. 312, Co. 421, Co. 285 and Co. L.5. By combining these the crushing period can be lengthened.

The All-India Station for breeding work on sugarcane is at Coimbatore (South India) where cane freely flowers. The cane rarely flowers in the Punjab. In order to evolve varieties suitable for the Punjab the cane breeders at Coimbatore are requested to cross the desirable parents and send the seed (Fluff) to Lyallpur, where the seedlings are raised and selections made. It takes about three to four years for these canes to be included in field trials. The varieties of cane bred at Coimbatore are known as "Co." while those raised at Lyallpur are called "Co. L."

Soil.

Except in some of the eastern districts, the rainfall is insufficient to grow cane. It is, therefore, mostly grown under irrigation, except as in river beds, where it can draw on underground water. It must have heavy soil for the best results.

Season.

Cane is usually planted in February-March, being generally planted earlier in the eastern districts. Planting in September was tried at Gurdaspur and in 1933-34 gave 1,195 maunds as compared to 704 *maunds* for March planting.

These results were confirmed in subsequent years, but similar tests at Risalewala were not so encouraging and again at Jullundur and Multan the autumn-sown cane gave poorer yields than the spring sown. One objection to September-planting is that the farmer loses a crop of *senji* by this practice, if his rotation is maize, *senji*, sugarcane, but the gain at Gurdaspur more than makes up for the loss of the *senji* crop.

Cultivation.

The cane-land requires a lot of presowing preparation. When it comes after fallow, about 10 ploughings are given. In case it follows *senji* there is not much time for cultivation and very intensive and thorough cultivation is done to prepare the field satisfactorily for the sowing of cane.

Rotations.

The commonest is maize, *senji*, sugarcane followed by either wheat or cotton.

Manure.

Manure is rarely applied direct to the cane crop ; it is usual to manure the previous crop. Freshly-applied manure attracts white ants which damage the young cane. It also tends to delay ripening. The previous maize crop, therefore, generally gets all the manure intended for sugarcane. The *senji* residue also adds nitrogen to the soil. The sugarcane crop is regarded as exhausting for the soil. When any farmyard manure is to be given direct and that is somewhat rare, it is applied in the winter months at least 2 months, preferably more, before planting.

In the case of *ponda* cane, used for chewing, a top-dressing of well-rotted manure is sometimes given to the young crop.

Manurial experiments. The amount of farmyard manure available is very limited and this is often a limiting factor in the spread of cane cultivation. Experiments were, therefore, laid out in 1934 at Lyallpur (Risalewala), to test the effect of ammonium sulphate and toria cake as supplements to farmyard manure. The results for 5 years ending 1938-39 are given below:—

Treatment (doses per acre)	Yield of *gur* per acre.	Value of *gur* per acre.	Price of manure.	*Gur* less value of manure.	Profit (+) or loss (—) over control.
	Mds.	Rs. a.	Rs. a.	Rs. a.	Rs. a.
1. Control 140 lbs. N in F.Y.M. ..	88·0	351 5	24 13	326 8	..
2. 70 lbs. N in F.Y.M. & 70 lbs. in Am. Sulph. ..	99·8	396 10	30 15	365 11	39 3
3. 70 lbs. N in F.Y.M. & 70 lbs. N in Toria Cake ..	105·3	417 15	39 11	378 4	51 12

It will be seen that replacement of half the farmyard manure by ammonium sulphate or toria cake giving the same nirtogen supply show a substantial profit. Note the comparatively high yields. Observation shows that toria cake generally gives better results than ammonium sulphate. The use of cake tends to assist the oil-crushing industry, for which a bright future is in store. The comparative value of different cakes as maunure and their optimum doses from economic point of view is under investigation.

The experiments had been made with phosphatic and potassic manures alone and in combination with nitrogen in varying doses but there was no response to phosphate or potash both at Jullundur and Risalewala.

Propagation. The seed of cane consists of short sections of the stem or tops containing usually two nodes or joints and buds. In the case of the thin indigenous canes the sets are thus about a foot long.

Treatment of sets varies considerably. In some parts the cane reserved for seed is left standing until required. In others, whole canes are buried in the ground in late November or early December until needed; sometimes the upper parts of the cane are taken out every day when the crop is being harvested and these are buried for use as sets. The tops make good sets and produce strong plants. The proportion of sugar in the tops is less so that the practice is economical from that point of view. It is commonly believed that cane grown from tops is late ripening—this has still to be proved. The object of burying sets is to protect them from frost, which in some years is very destructive to sugarcane. It causes inversion in the juice—sucrose is changed into glucose and quality of *gur* consequently deteriorates. The frost also kills the buds and renders them unfit for seed. The damage from frost can be greatly mitigated by securing thick stand of the crop, vigorous growth by adequate manuring and watering and by preventing lodging of cane.

Quantity reserved for seed.

In the case of the thin Punjab canes, which tiller well, only 1-20th or 5 per cent of the area of cane needs to be reserved for sets where the whole cane is used. In the case of Coimbatore canes, the tillering is less and ten per cent. of the crop has to be reserved for seed.

The stand of the cane-crop is often poor in cultivator's fields and this is due to insufficient seed or sets with dead buds being planted. For a good stand it is necessary to have 40,000 healthy sets per acre. The sets should be planted end to end and not 6 or more inches apart as is often done by cultivators.

Sowing.

The land is irrigated and ploughed and then levelled once or twice. The land must be exactly right as regards moisture at the time of planting. The sets are placed by hand in furrows made by the country plough. The furrows are one foot apart. In rich soils it has been found best to sow cane two feet apart in trenches or on flat. The subsequent earthing up is completed before the rains and is usually done in two or three operations ; this prevents lodging. A further advantage of this method is that interculture with bullock-drawn implements is possible and thus a larger area can be managed. On poor soils, closer planting, say 12 inches to 14 inches, has been found to produce higher yields.

Hoeing and Weeding.

The crop is hoed frequently. The first hoeing is often done before the crop is visible and before the first irrigation. It is subsequently hoed after each irrigation. The total hoeings are six or seven and never less than three. The first hoeing is done with a special implement called *baguri*, others with *kasola*; the last hoeing is deep and is preferably done with a *kahi*.

Watering.

First watering may be delayed for two weeks but after that the cane crop requires watering every ten days up to early July. The subsequent waterings are done every 14 days and later every twenty days. This is the practice in the absence of any rain. In such years the cane requires about 20 waterings. Normally rain replaces some of the waterings. The total quantity of water used is probably from 50 to 60 inches. Thick cane requires even more and often consumes as much as 70 or 80 inches.

Irrigation experiments at Lyallpur (Risalewala), have shown that frequent waterings after 10—12 days are better than those after 15—18 days. The yield and sucrose content is also enhanced by frequent waterings. Exact measurements of the water required by the cane crop are being worked out.

Diseases and pests.
Red Rot.

The interior of canes suffering from this disease becomes red. Red rot affects thick canes mostly and attacks thin canes only to a small extent. The disease is nearly always carried through sets from a diseased plant. Consequently care should be taken to plant healthy sets.

Smut

This is a fairly serious disease of sugarcane both in *desi* and improved canes. The affected plants can be noticed from a distance as they give out a black whip-like shoot. It is carried through ane sets from a diseased plant. The remedy, therefore, is o plant healthy sets. The degree of further infection can e reduced if the diseased plants are completely rogued ut and burnt.

Striga.

Striga is a flowering plant and grows as a parasite on the roots of sugarcane and *jowar*. It has been noticed in the districts of Ludhiana, Gurdaspur, Gujranwala and Shahpur. It sucks up the food naterial from the host plant which consequently suffers nd in some cases may be killed. It is propagated by neans of seeds. The flowers come out in September and eeds mature in December. The striga plants should be onstantly weeded out before the appearance of flowers. The affected field should be kept fallow or an immune crop hould be grown after sugarcane.

Sugarcane borers.

There are two types of borers—top borers and stem borers. The general symptoms of attack and methods of control of both are almost imilar. These borers are a serious pest of sugarcane. Ordinarily 12 to 24 per cent. of the plants may be lamaged but when the attack is severe as many as 75 er cent. of the canes may be affected. The moths emerge rom the stubbles of the previous crop in case of stem borer nd from tops of standing crop in top borer and lay eggs n clusters on the tender leaves. Young caterpillars on atching bore into the cane shoots. The central leaf is illed. It withers up and produces a 'dead heart.' The rowth of the attacked plants is retarded, and they produce econdary shoots and thus develop 'bunchy' tops. The ttack of the borers weakens the plants and reduces the ugar content.

The cheapest and the most effective and practicable nethod of control for stem borer is the safe disposal of tubbles. These should be collected and burnt or buried leep so that the moths are destroyed and are unable to reed further.

As the eggs are laid in clusters and are conspicuous on he leaves, they can be easily collected and destroyed.

As soon as the 'dead hearts' are noticed they should be regularly cut and destroyed. In case the 'dead hearts' are only pulled out, the sanitary fluid should subsequently be poured into the holes by means of small oiling cans.

The moths are attracted to light. Advantage can be taken of this fact and light traps employed with advantage. One lamp is enough for 5 acres.

Some parasites have been noticed to destroy the eggs of borers. As far as possible, these should be encouraged.

Pyrilla.

Sugarcane Pyrilla is also known by the name of Sugarcane Fly or Sugarcane Leaf Hopper. In vernacular it is commonly known as "*ghora.*" It is a very serious pest and in certain years has done considerable harm particularly to the soft varieties having broad and succulent leaves.

The adult is a winged insect with a protruding head. The eggs are laid in clusters usually on the underside of the leaves. The nymphs and the adults suck juice and exude thick transparent liquid popularly known as 'Honey-dew.' The presence of this material on the leaves gives rise to a black fungus which interferes with the proper functioning of these leaves. The vitality of the plant suffers both on account of the sap being sucked by the insects and the detrimental effect of the fungus. The adults can be collected by means of hand nets. This operation should be performed during the latter part of April and early May. Hand-netting should be done in the morning because the adults are sluggish and inactive in the early hours.

The eggs being laid in clusters are easily noticeable and can easily be destroyed by rubbing the clusters between the thumb and the forefinger early in the season.

Pyrillid Borer.

A new type of borer has lately been noticed. It is prevalent in Gurdaspur and Hoshiarpur. Like stem borer, it hibernates in cane stubbles. The moths on emergence lay eggs on tender leaves and caterpillars make a spiral cut in the cane.

The first brood begins attack in June-July. The only remedy so far suggested is to remove the effected shoots and bury them deep in the ground.

Harvesting

The cutting and stripping of cane is generally done by family labour supplemented by casual labour, which is recompensed by the value for fodder of the tops and upper leaves which the cutters are allowed to take away. Generally speaking the ratio of tops to stripped canes is about 1 to 3 in the case of Co. varieties and slightly more in *desi* types.

The Coimbatore canes can be stripped more easily than the *desi* varieties. A man can harvest and strip about 1½ *maunds* of Co. canes per hour as against only 20 to 30 seers in the case of *desi* types and the harvesters obtain about 2 to 3 times as much tops in the former case than in the latter.

Crushing and boiling.

The crushing and boiling is carried out by the farmers themselves, and it occupies most of their time as a rule during the months of December and January. The furnace feeder is invariably hired. In south-eastern Punjab the cultivators do not make *gur* themselves and engage *jhiwars* from U.P. for this purpose.

The cane crushing mills used are small iron ones with vertical rollers and worked by bullocks. The old wooden mill is now seen very rarely. Of the many types, the Batala mill and the Nahan mill are the most common. The former costs about Rs. 50 to Rs. 80 and the latter about Rs. 135. As regards the percentage of juice expressed, Nahan mill is superior to Batala type, the percentages being 61 and 57 respectively. It will, thus, be seen that about 4 per cent of juice is lost by the use of Batala mills. The cane crushers are invariably owned by the cultivators except in the south-eastern Punjab where the usual custom is to hire a mill along with pans jointly each season and at exorbitant rates.

The juice after extraction is boiled down in a small shallow pan about 4½ feet in diameter and costing about Rs. 15. It usually holds three earthen *mats* or kerosene tins full of juice, each having about 21 *seers*. A boiling pan contains, therefore, about 62 to 63 *seers* of juice. From 12 to 16 boilings a day of 24 hours can be done with one furnace. Three to four men are required to do the crushing and boiling. In the eastern Punjab, boiling is done in two or three pans at a time. During boiling, the scum which collects on the surface is periodically removed with a long handled sieve. In Jullundur and Hoshiarpur, the people often use the extract of the bark of a plant called *suklai* (*Kydia calycina*, Rox) for clarifying the juice. In Gurdaspur, if the season has been wet and the cane not properly ripe, lime is often used for clarifying. Sometimes soda-bicarbonate and decoction prepared from *bhindi* bark are also utilized. Experiments have shown that best results are obtained by a combination of *suklai* decoction and some minerals. Five seers of *suklai* rubbed in 2 *maunds* of water are enough for clarifying 100 *maunds* of juice. After the addition of *suklai* decoction half a lb. of solution of soda ash 1 lb. and soda-sulphate 2 ounces in 20 *seers* of water is added. Activated carbon has also been tried with good results. It can be obtained from Calcutta at Re. 0-2-0 per *seer* F.O.R. Calcutta. By the use of clarifiers a better-coloured *gur* is obtained.

When the boiling juice becomes somewhat thick in consistency it is stirred vigorously with a wooden *gadoa*. After sometime when about four-fifths of the original juice is evaporated the contents are poured into a flat earthen circular pan termed as *gand* and is allowed to cool. It is again stirred with *khurpa* and is finally allowed to set.

Gur.

When the product is still warm, it is made into lumps. In Jullundur and Hoshiarpur districts, *gur* is made into small cakes known as *pesis* weighing from one *chhatak* to four *chhataks*. In other parts of the province, lumps varying from about 2 lbs. to 10 lbs. in weight are put on the market. In Gurdaspur, Gujranwala and Sialkot districts, small *bhelis* (*roris*) weighing about one to two *seers* are in vogue. In Ambala and Karnal districts, the *bheli* usually weighs three *seers* and the *gur* is known as *tinsera*. In the south-eastern districts like Rohtak and Gurgaon, the *bhelis* weigh four and five *seers* each; and the *gur* is known as *chausera* and *pansera* respectively.

In the Punjab, only eating *gur* is made, and the refineries whenever they work, have to import large quantities from U.P. and Bihar. The recovery of sugar from imported refining *gur* is said to be higher than that from the local eating *gur*. This is due to the fact that the eating *gur* is prepared at comparatively high temperature and some sugar is lost due to charring and carmelization. The refining *gur* on the other hand, is struck at a lower temperature, *i.e.*, at 114°C or 115°C as against 118°C in the case of eating *gur*. As an experimental measure, refining *gur* was prepared at the Jullundur Agricultural Farm, and the tests carried out at Sonepat Sugar Factory (now defunct) showed that this *gur* compared favourably with the imported quality.

Out of the various types of imported eating *gur*, *pansera*, *chaku*, *barfi* and *laddu* are the important ones from U.P. *Pansera gur* is in the form of lumps each weighing 5 *seers*. *Chaku gur* is in the form of slabs with three or four layers which can be separated with a sharp-edged weapon like a knife. *Barfi gur* resembles *chaku gur* but is single layered. *Laddu gur* is in the form of small balls weighing about one or two *chhataks*. The imports from North-Western-Frontier Province consist almost entirely of *laddu gur*.

Besides this, appreciable quantities of *minja* are imported from U.P. *Minja* is more crystalline than *shakkar* but resembles it in colour. Some poor people use it in place of sugar. It is also fed to cattle in small quantities in certain tracts for increasing milk yield particularly to freshly calved animals.

Shakkar.

For making *shakkar* the juice is boiled longer than when making *gur* and a loss of 5-10 percent. or so in weight results. After cooling, the mass is broken up into small pieces, by rubbing with hands.

Generally one hundred *maunds* of stripped cane will give 56 to 65 *maunds* of juice with Nahan mill and this will yield 10 to 11 *maunds* of *gur*, and 9 to 10 *maunds* of *shakkar*.

Rab is manufactured in the province on a very small scale. It is mainly used for the production of indigenous sugar in *khandsari,* though small quantities are utilized for eating purposes also. The method of making *rab* is the same as for the production of *gur* except that the juice is boiled to a lesser consistency. The outturn of *rab* from juice is, therefore, higher than that of *gur* by about fifteen to twenty percent.

Rab

There are two types of *khandsari* sugars; one made from *khanchi* and the second prepared with open pan.

Khandsari Sugar

(*a*) *Khanchi*. A *khanchi* 6¾'x3¾'x4½' can hold about 200 *maunds* of *rab*. Temporary channels for the flow of molasses are made on the floor by placing bricks and an outlet for molasses is made in the *khanchi*. A layer of cotton-sticks is placed on the bricks and a thick cloth usually *khaddar* is spread over it. The walls are lined on all sides with matting. *Rab* is put on the cloth. After about ten days one inch layer of *jala* (*Hydrilla verticillata*) is put on the *rab* and weight is placed over it. The layer of *jala* is renewed occasionally. *Jala* serves as a bleaching agent. Sugar is taken out of the *khanchi* in about a dozen instalments. The average recovery of sugar from *rab* is about 29 percent.

(*b*) *Centrifugals*. *Rab* is allowed to rest undisturbed for a period of about 10 days in order to allow for proper crystallisation. Subsequently it is well rubbed and the lumps are broken. *Rab* is then put into a centrifugal which may either be worked by hand or mechanical power. When about three-fourth of the molasses has been removed washing with a syringe containing hot water is given. With more washing, the sugar produced is of whiter colour but the crystals are of smaller size and *vice versa*. Under ordinary conditions of working the recovery of sugar from *rab* is almost the same as in the case of *khanchis*.

The essential difference between the vacuum pan and open pan systems is that in the former juice is boiled in a vacuum so that boiling takes place at a lower temperature than the open pan system. Thus the charring of sucrose is eliminated and recovery of sugar is more.

Vacuum pan system.

The Government of India converted the revenue duty on sugar into a protective duty from 1st April, 1932. With the grant of protection, the sugar industry made a miraculous progress and from 32 cane crushing factories in 1931-32 the number jumped to 151 in 1943-44. The total Indian production of sugar from all sources increased from 3,10,918 tons in 1929-30 to 13,26,400 tons in 1943-44. This resulted in a large diminution of imports. The volume of imports at its maximum, prior to the imposition of duty was about one million tons. In 1937-38, however, the figure was only 9,000 tons and in 1942-43 only 563 tons. As a result of the protective duty India has now attained a position of self-sufficiency. The history of the import duty is set out below in chronological order.

Import duty on sugar

Excise Duty and Import Duty on Sugar, Sugar Candy and Molasses in India.*

Period	Protective *Import Duty* per cwt.	*Additional Revenue Duty* per cwt.	*Total Import* Duty per cwt.
	Rs. a. p.		Rs. a. p.
From 1st April, 1932 to 31st March, 1934. ..	7 4 0	Revenue surcharge at 25 per cent. of protective duty Rs. 1-13-0 ..	9 1 0
From 1st April, 1934 to 27th February, 1937 (Rs. 1-5-0 Excise Duty on domestic production of factory sugar).	7 12 0 (As. 8 being additional margin).	Equivalent excise duty Rs. 1-5-0 ..	9 1 0
From 28th February, 1937. (Rs. 2 Excise Duty on domestic production of factory sugar).	7 4 0	Equivalent excise duty Rs. 2. ..	9 4 0
From 1st April, 1939. (Rs. 2 Excise Duty on domestic production of factory sugar)	6 12 0	Equivalent excise duty Rs. 2	8 12 0
From 1st March, 1940. (Rs. 3 Excise Duty on domestic production of factory sugar). ..	6 12 0	Equivalent Excise duty Rs. 3. ..	9 12 0
From 1st April, 1942. (Rs. 3 Excise Duty on domestic production of factory sugar).	6 12 0†	Revenue surcharge of 20 per cent. amounting to Rs. 1-5-7$^1/_8$ and equivalent excise duty Rs. 3.	11 1 7$^1/_8$

*From 20th February, 1934, a revenue duty of Rs. 10-8-0 per cwt. was imposed on sugar candy in place of Rs. 9-1-0 per cwt. The rate of import duty on molasses is 31¼ per cent. *ad valorem* since April, 1932.

†This import duty has been continued till 31st March, 1946.

From 1st April, 1934, however, excise duty on internal production was levied at Re. 1-5-0 and Re. 0-10-0 per cwt. on sugar produced in *vacuum pan sugar mills and open pan khandsari* establishments respectively. This excise duty was further enhanced to Rs. 2 per cwt. and Re. 1 per cwt. on sugar produced from sugar mills and open pan factories respectively from 28th February, 1937. This had an adverse effect upon the sugar industry of the province and nine of the sugar mills and refineries were closed down. The number of open pan factories using centrifugals also went down from 84 in 1932-33 to 14 in 1937.

Excise duty

With effect from 28th February, 1939, the Excise Duty on *khandsari* sugar was reduced from Re. 1 to -/8/- per cwt. and that on factory sugar was increased to Rs. 3 per cwt. from 1-3-40. In November, 1943, and in October, 1944 special additional excise duties at the rate of Re. -/13/- and Re. 1/7/- per *maund* respectively were also imposed on all sugar produced in any factory in British India before the commencement of these orders and owned and possessed at the commencement of these orders by owner of factory or by a wholesale dealer. The rate of this special duty for *khandsari* sugar was Re. 1 per *maund* in 1944.

With the introduction of improved Coimbatore varieties which are more juicy than the *desi* types, it was found that the local furnace could not boil the juice with the available begasse and trash and that good deal of extra fuel was needed. It was also found that the output of the local furnace was far below the capacity of the iron mill crushing Coimbatore varieties. The primitive indigenous furnaces besides having a low boiling capacity and a high fuel consumption are defective in that it is difficult to prepare *gur* of good and uniform quality on them. The boiling pan is quite often fixed and the finished product has to be ladled out. As the pan remains on the fire all this time, the quality of the *gur* obtained is adversely affected due to burning and charring.

Furnaces

In order to remove these defects several improved furnaces such as Jullundur special, Sardar furnace, etc. have been evolved. These furnaces not only boil more juice per hour but consume smaller quantity of fuel. For instance the Jullundur special can dispose of 2·75 *maunds* of juice per hour as against 1·2 *maunds* in the case of *desi* furnace. The fuel consumed per 100 *maunds* of juice is 36·33 *maunds* in the case of former as against 55·00 *maunds* in the case of latter.

Relation of Sugar and *Gur* prices.

The following table gives the average annual prices of first quality sugar ex-mill Cawnpore and *gur* quoted in the Lyallpur market from 1935 to 1943.

Year.		Average annual price of					
		Sugar			*Gur*		
		Rs.	A.	P.	Rs.	A.	P.
1935	..	9	0	0	5	1	0
1936	.. ..	8	4	0	3	15	6
1937	.. ..	7	0	0	2	12	6
1938	.. ..	8	8	0	3	5	9
1939	.. ..	10	12	0	5	9	5
1940	.. ..	10	8	0	5	13	11
1941	.. ..	11	0	0	3	1	0
1942	.. ..	13	0	0	3	14	1
1943	.. ..	15	0	0	9	2	10

Since April, 1942, the price and distribution of sugar has been controlled by the Government of India.

Cost of cultivation and yield of *gur* from an acre of sugarcane crop.

The summary of average cost of production of sugarcane at Risalewala Farm* for the five years (ending 1931-32) is given below :—

	Rs.	A.	P.
Manual labour (106·9 days)	33	6	5
Bullock labour (29·9 days)	43	2	10
Water rates	12	0	0
Seed	15	8	6
Manure	14	15	7
Implements	11	7	10
Kamins	0	9	2
Jhoka	7	11	7
Total ..	138	13	11
Value of juice	4	9	10
Cost of *gur*	134	4	1
Gross income	211	9	9
Balance	72	11	10
Yield per acre in *mds.*	50	10	1
Cost per *maund* of *gur*	2	10	9

In the above figures, wages for harvesting sugarcane have not been included in the cost nor the value of tops in the income. Land Revenue and cesses which together amount to Rs. 7-0-9 per acre have also been excluded. The rental value (excluding the amount of land revenue) which worked out at Rs. 29-1-2 per acre on the average has also been left out as an item of cost. Family human-labour was charged @ Re. -/5/- per day of 8 hours each.

The cost of production of sugarcane as arrived at in the cost of cultivation of crops enquiry conducted from 1933-34 to 1935-36 under the aegis of the Imperial Council of

*Studies in the cost of production of crops in the Punjab by S. (now S. B.) Kartar Singh, B.Sc., L.Ag., The Board of Economic Enquiry, Publication No. 33.

Agricultural Research and Indian Central Cotton Committee, is given below:—

Rate	Place	Sugarcane *Desi.*	Sugarcane Coimbatore.
		Rs. a. p.	Rs. a. p.
Cost per acre ..	Lyallpur ..	101 9 2	113 15 2
	Jullundur ..	159 8 4	200 6 6
	Gurdaspur ..	105 12 2	..
Cost per *maund* ..	Lyallpur ..	5 2 4	4 6 7
	Jullundur ..	9 1 9	5 14 4
	Gurdaspur ..	5 15 4	..
Gur prices ..	Lyallpur ..	4 1 0	4 2 0
	Jullundur ..	4 8 6	3 13 6
	Gurdaspur ..	3 15 0	..

The cost of production given above includes land revenue, rental value (minus land revenue) other cesses, interest on working capital besides other items of expenditure. In working out the cost per maund, allowance has been made for the value of by-products.

References.

(1) Agricultural Statistics of India.

(2) Estimates of Area and Yield in India.

(3) Reports on the Season and Crops of the Punjab.

(4) Reports on the operations of the Department of Agriculture, Punjab.

(5) A summary of more important results arrived at or indicated by the Agricultural Stations and Research Officers in the Punjab 1930-31 to 1934-35 and 1935-36 to 1937-38 Department of Agriculture, Punjab.

(6) Report on the Marketing of *Gur* in the Punjab (unpublished).

(7) Indian Sugar Industry Annuals by M. P. Gandhi.

(8) Annual Reports of the Water Requirement Scheme.

(9) Studies in the Cost of Production of Crops in the Punjab by S. (now S. B.) Kartar Singh, Board of Economic Inquiry Publication No. 33.

(10) Report on the Cost of Production of Crops in the Principal Sugarcane and Cotton tracts in India, Vol. I— The Punjab—1938, Imperial Council of Agricultural Research.

(11) Department of Agriculture, Punjab, Leaflets Nos. 18, 22, 24, 37, 63, 89, 110, 112, 116, 147, 159, 174, 187, 193, 195.

CHAPTER XIV

OTHER FOOD CROPS

FRUITS AND VEGETABLES

Main food constituents

Up to about 25 years ago it was customary to regard proteins, carbohydrates and fats as the only vital and important constituents of food. Proteins, in which such foods as eggs, red meat or lean meat and pulses are rich, constitute the flesh-forming element in foods. Carbohydrates and fats supply energy and heat to the system. These constitute the three main elements of foods and it is to the percentages of these in foods we look to see their relative values. Minerals, which supply no energy are also essential in food, particularly for bone formation and, therefore are an important constituent for foods for the young—whether human or animal. Fruits and vegetables contain sufficient mineral matter, and are valuable for that reason, as well as, for the carbohydrates and sugars which they contain.

It is in respect of vitamins however, that fruit and vegetables are particularly important. The vitamins were isolated and studied only a quarter of a century ago. They exist in minute quantities and are unstable in composition and, easily destroyed. Carrots which are rich in vitamin A only, contain 2020 International units per hundred grams. A brief summary of our present knowledge about them is given below:

Other valuable factors in fruits and vegetables.

Besides the above main factors many vegetables and fruits contain organic acids, which impart flavour and makes food palatable. Some are also important sources of proteins and carbohydrates. Glucose and sugar present also can be assimilated direct into the blood stream and, therefore, provide readily available energy. Cellulose and pectic substances stimulate peristaltic movements of the lower intestine and tend to keep the digestion in smooth working order. As a source of roughage also giving the necessary bulk to our food both vegetables and fruit perform a useful function.

Vitamins.

(Vita means life, *i.e.*, life-giving substances). Although vitamins occur in very minute quantities in foods and their chemical composition and quantitive differentiations are not fully known, yet their presence or absence are known to produce marked and specific effects on the human body. Like the ignition spark of an automobile or what is known as a catalytic agent in chemical reactions, their presence makes it possible to make the best use of foodstuffs and promote normal growth and maintenance of good health and reproduction. In the case of some deficiency diseases each vitamin has a specific preventive and curative action. So far seven vitamins have been clearly differentiated. They are A, B, C, D, E, G, and H. If any of these vitamins is totally absent from the food for a long time, death results. One vitamin cannot replace the other. Cooking, drying and preservation of foods has harmful effect upon most of the vitamins. Very few foods contain all the vitamins.

As vitamins are found in very minute quantities, special units called the International units have to be used for their measurement. These units vary with each vitamin as shown below.

Vitamin A.—One International unit of vitamin A is equal to 0·6 micromilligram of International standard of B. Carotene.

Vitamin B.—One International unit of vitamin B is equal to 0·01 gm. of thiamin.

Vitamin C.—One International unit of vitamin C is equal to 0·05 mgm. of ascorbic acid.

Vitamin D.—One International unit is the activity of 1 mgm. of irradiated Ergosterol in olive oil kept at the National Institute of Medical Research.

Vitamin A. (Carotene)

Is fat soluble and is generally found in animal fats, except lard. Cod liver oil, other fish oils, whole milk, curd, butter, unadulterated ghee and egg yolk contain appreciable quantities of this vitamin. Vegetables generally do not contain this vitamin but the pigment carotene, which is present in many vegetables, such as carrots, spinach, lettuce, cabbage, coriander, tomatoes, etc., and ripe fruits, such as mangoes, papayas, etc., appears to fulfil the function of vitamin A. An absence of this vitamin increases the incidence of catarrhal diseases and xerophthalmia (an eye disease), night blindness, formation of kidney and bladder stones, dryness, pimples, roughness and eruptions of skin and brittleness of teeth, etc.

Vitamin B_1. (Thiamin).

This is a water soluble vitamin and is composed of B_1 and B_2. Vitamin B_1 is antineurotic or anti-beri-beri and is commonly called vitamin B_1 while B_2 also known as vitamin G promotes growth. Vitamin B_1 is found in unmilled cereals, pulses, eggs, fruits, nuts, most vegetables, glandular organs, such as liver and to some extent in muscle meat and milk. The absence of B_1 gives rise to beri-beri, a disease characterised by changes in the nervous system, loss of sensitivity of skin, paralysis legs, and infiltration of fluid into arms and legs and enlargement of the heart, loss of appetite, and weight and fall in body temperature.

Vitamin C. (Ascorbic acid).

This is water-soluble and is generally present in fresh fruits, especially citrus fruits and raw vegetables. Leafy vegetables are the best sources of this vitamin. When such vegetables become dry and stale this vitamin is destroyed—pulses and cereals in ordinary state have no vitamin C, but when they are allowed to sprout it is found in the green growing sprouts. Oranges, lemons, tomatoes, carrots, apples, bananas and raw milk contain appreciable quantity of vitamin C. Dried fruit, dried vegetabes, and milk heated for a long time, vegetables cooked with soda, turnip and beetroot do not contain this vitamin. While slow cooking at a relatively low temperature destroys vitamin C, rapid cooking at a higher temperature does not destroy it. The absence of this vitamin is responsible for scurvy disease of the whole system characterised by pains in the joints, swelling of limbs and bleeding of gums under the skin. It is also responsible for the prevalence of tooth decay, rheumatism in children and adults. The breath becomes offensive and teeth spongy and loose. The disease can be cured by just taking fresh fruits and lemon juice.

Vitamin D. Is fat soluble and its absence causes rickets, a disease of bones, caused by upsetting of the balance of calcium and phosphorus in the blood. Rickety children suffer from convulsions, bow-leggedness and are very easily susceptible to broncho-pneumonia. Vitamin D is found in liver and liver oils, egg yolk and in milk and milk fat. Vegetable oils and *vanaspati ghee* and oils do not contain this vitamin. Vitamin D is also formed in the skin by the action of sunlight. Rickets are, therefore, commonly found in infants and women kept in dark houses or *purdah*. The cheapest source of this vitamin is, therefore, exposure of body to the sunlight.

Vitamin E. Is fat-soluble and promotes fertility. It is generally present in whole wheat, egg yolk, liver, leafy vegetables like cabbage, lettuce, and vegetable oils. Cod liver oil, lard and milk do not contain this vitamin. Absence of this vitamin affects the reproductive organs and causes sterility.

Vitamin G. (B_2). (Riboflavin). This is a growth-promoting water soluble vitamin. All cereal foods are poor sources of it, milled rice being the poorest. Some of the common pulses, such as gram, however, contain a fair amount. Green leafy vegetables and some roots and tubers are fairly rich, but fruits in general do not contain much of this vitamin. The richest sources are yeast, milk products (including skimmed milk, butter milk, curd and cheese) lean meat, liver, eggs, pulses and green vegetables. Deficiency of this vitamin causes loss of appetite and weight, sore mouth and development of cataract and swollen nose. It is essential for growth and health of the skin.

Its chemical nature has so far not been elucidated.

Vitamin H (B_6) or (Y).

It has, however, been proved to be essential for the growth and health of the skin in rats. Lack of this vitamin causes actual inflammation of the paws, nose and ears in the rat.

Mineral elements

Elements such as calcium, phosphorus and iron are required by the human body in large quantities and some vegetables and fruits are an important source of all these elements. In addition, iodine, though present in minute quantities, is also obtained from vegetables and is of special importance. These minerals are helpful to the body in building of tissues and also in regulating the various body activities, such as those of nerves, glands and muscles. Calcium is essential for the control of contractibility of muscles, particularly of the beating of the heart. Phosphorus is necessary for all active tissues of the body, being required for the cell multiplication of bones and soft tissues. It is also required for the regulation of the neutrality of the blood. The red colour of the blood cannot be formed without iron salts. Iodine, though required in very minute quantity, is very essential for the functioning of thyhroid gland and for normal growth and good health. Deficiency of iodine in Kangra is one of the main causes for prevalence of goitre. Many other salts are also essential for regulating the work of different organs. But all these salts will be sufficiently provided to the body in case variety of food is taken. Leafy vegetables such as spinach, cabbage, coriander and mint are a rich source of vitamins and minerals.

The accompanying table shows the mineral and vitamin contents of vegetables and fruits—page 332 to 335.—(Adapted from "Health Bulletin", No. 23).

CARBOHYDRATE, MINERAL AND VITAMIN CONTENTS

(Adapted from "Health Bulletin," No. 23, 1937, Indian Research Fund Association, Coonoor.)

Kind of vegetable.	Carbo-hydrates.	Minerals: Calcium.	Minerals: Phosphorus.	Minerals: Iron (Mgs.)	Vitamins: Carotene International Vitamin A units per 100 gms.	Vitamins: Vitamin B_1 International Units per 100 gms.	Vitamins: Vitamin B_2	Vitamins: Vitamin C (Mgs. per 100 gms.)
	Per cent.	Per cent.	Per cent.	Per cent.				
1. Brussels sprouts ..	9·27	0·015	0·082	12·33	..	..	..	71·8
2. Cabbage ..	6·38	0·034	0·046	0·76	2,000	50	..	124·2
3. Celery ..	8·62	0·226	0·137	6·25	5,760 to 7,470	Trace	..	62·4
4. Coriander ..	6·52	0·137	0·058	9·97	12,630	..	++	135·2
5. Fenugreek ..	9·89	0·472	0·047	16·90	3,860	..	..	..
6. Lettuce ..	3·04	0·051	0·030	2·39	2,200	90	..	14·9
7. Mint ..	8·10	0·204	0·077	15·56	2,700	..	..	..
8. Parsley ..	19·71	0·392	0·195	17·86	3,200	..	..	280·8
9. Spinach ..	4·07	0·061	0·010	4·95	2,630 to 3,000	70	..	47·7
10. Beet root ..	13·74	0·195	0·057	0·98	0	70	..	88
11. Carrot ..	10·75	0·082	0·030	1·52	2,020	60	..	2·5
12. Parsnip ..	23·19	0·048	0·041	0·40	30	105	..	16

13.	Potato ..	22·80	0·004	0·034	0·68	40	40	++	17.3
14.	Radish (pink) ..	7·46	0·046	0·017	0·47	3	60	..	16·9
15.	Radish (white) ..	4·25	0·054	0·025	0·40	3	60	..	15·0
16.	Sweet potato ..	30·89	0·017	0·050	0·79	10	..	++	24·0
17.	Amaranth, stem ..	3·51	0·263	0·034	1·80	..	..	..	..
18.	Ash gourd ..	3·18	0·025	0·017	0·45	Trace	21	..	0·9
19.	Bitter gourd ..	4·26	0·023	0·065	2·22	210	24	Poor	88·4
20.	Bitter gourd (small variety)	9·86	0·045	0·144	9·35	210	24	..	88·4
21.	Brinjal ..	6·44	0·024	0·064	1·31	5	..	+	22.5
22.	Broad beans ..	9·98	0·045	0·055	1.61	..	..	..	12·2
23.	Calabash cucumber ..	2·67	0·015	0·003	0.69	Trace	..	..	..
24.	Cauliflower ..	5·29	0·034	0·061	1.25	38	110	..	65·8
25.	Celery stalks ..	3·53	0·033	0·038	4.76	..	..	..	5·7
26.	Cluster beans ..	10·10	0·129	0·051	5.76	330	..	..	49·4
27.	Cucumber ..	2·76	0·012	0·025	1·48	Trace	30	..	6·9
28.	Double beans ..	16·76	0·030	0·142	2·27	..	..	..	22·4
29.	French beans ..	4·30	0·048	0·025	1·67	221	26	..	13·9
30.	Knol-Khol ..	5·98	0.023	0·035	0·40	..	..	..	84·5
31.	Ladies fingers ..	7·76	0·094	0·078	1·54	58	21	+	15·6
32.	Leeks ..	17·15	0·052	0·073	2·30	..	75	..	10·7
33.	Onion, stalk ..	8·81	0·048	0·054	7·50	..	..	..	..
34.	Peas, English ..	19·86	0·019	0·078	1·47	139	120	..	9·2
35.	Pumpkin ..	5·39	0·009	0·030	0·67	84	20	..	2·0
36.	Ridge gourd ..	3·59	0·035	0·040	1·58	56	22	..	..
37.	Snake-gourd ..	4·47	0·045	0·024	1·28	160	..	..	Trace.
38.	Spinach stalks ..	3·80	0·090	0·015	1·34	..	..	..	2·9
39.	Tomato, green ..	4·57	0·018	0·039	2·37	320	23	..	31·3
40.	Turnip ..	7·52	0.028	0·035	0·42	Trace	40	..	43·4

CARBOHYDRATE, MINERAL AND VITAMIN CONTENTS

(*Adapted from "Health Bulletin," No.* 23, 1937, *Indian Research Fund Association, Coonoor.*)

Kind of fruit	Carbohydrates	Minerals			Vitamins.			
		Calcium	Phosphorus	Iron (Mgs.)	Carotene* (International Vitamin units per 100 gms.)	Vitamin B_1* (International Units per 100 gms).	Vitamin B_2	Vitamin C (Mgs. per 100 gms.)
	Per cent.	Per cent.	Per cent.	Per cent.				
1. Apple ..	13·40	0·013	0·021	1·68	Trace.	40	..	2·1
2. Banana ..	36·41	0·002	0·045	0·42	Trace.	50	..	1·0
3. Grape (Blue variety) ..	10·13	0·025	0·019	0·40	15	Trace	..	2·5
4. Grape-fruits (Triumph variety)	7·02	0·017	0·021	0·18	..	40	..	31.2 *juice*
5. Grape-fruits (Marsh's seedless Var.) ..	10·13	0·025	0·027	0·20	..	40	..	31·2 juice
6. Lemon ..	11·29	0·070	0·014	2·33	..	..	..	38·5 *juice*
7. Lime ..	11·08	0·091	0·021	0·29	120	..	..	62·5 juice
8. Orange ..	10·56	0·046	0·022	0·08	350	40	..	67·7
9. Mango (green) ..	8·84	0·012	0·017	4·48	150	..	..	3·2
10. Mango (ripe) ..	11·69	0·007	0·020	0·25	4,800	..	Poor	..
11. Mango (Ankola) ..	12·46	0·004	0·016	0·45	1,860	..	..	23·6

12. Guava (country var.) ..	14·57	0·013	0·040	1·04	100	..	..	299·0
13. Date (Persian) ..	67·31	0·067	0·076	10·58	600	+	+	Trace (Preserved fruits)
14. Papaya ..	9·50	0·013	0·009	0·42	2,020	..	..	45·5
15. Peach ..	7·64	0·006	0·029	1·70	Trace.	..	..	1·0
16. Pear (country) ..	11·58	0·006	0·011	0·68	14	..	..	Trace
17. Pear (English) ..	12·76	0·005	0·016	0·84	80	30	..	1·0
18. Pine apple ..	12·00	0·021	0·007	0·92	98	..	..	62·9
19. Plum (Red var.) ..	8·92	0·017	0·018	0·55	230 (Yellow variety)	40	..	0·6
20. Pomegranate ..	14·56	0·009	0·066	0·27	..	..	..	15·6
21. Strawberry ..	9·77	0·026	0·026	1·75	..	..	..	52·0
22. Fig ..	17·02	0·055	0·026	1·16	..	..	..	2·4
23. Almond ..	10·50	0·225	0·492	3·47	..	80	..	..
24. Cashewnut ..	22·29	0·053	0·449	4·95	100	..	+	..
25. Pistachionut ..	16·25	0·136	0·431	13·70	..	..	..	..
26. Walnut ..	10·90	0·095	0·334	4·76	..	150	..	..

See " Bulletin " No. 178 Council of Scientific and Industrial *Research Australia*.

*One International Unit of Vitamin A is defined as the activity of 0.0006 *miligrams of beta-carotene.*

†One *International Unit of Vitamin* B_1 is defined as the potency of 3 micrograms of pure thiamin hydrochloride.

It will be observed that green leafy vegetables are an important source of vitamin A and vitamin C. They also provide a considerable quantity of vitamin B, of iron and calcium. The orange or yellow coloured vegetables are an important source of carotene. Tomato is a well-known source of vitamin C. It also contains carotene and some of the B vitamins. Fruits in general are good sources of vitamin C especially the citrus fruits. Vitamin B_1 is present in apples, bananas, dates, pears (English), grape fruit and oranges. It will further be observed that tropical fruits are richer in their vitamin contents than those grown in the temperate regions. Since mangoes and citrus fruit predominate in the fruit industry of this province, our position is enviable in this respect.

Tabloid vitamins.

Many of the vitamins are now available in the market in powder or tablet forms. Since the exact vitamin requirements for man are not known, the use of synthetic products available in the form of pills, for the purpose of making up nutritional deficiencies is hazardous. It is, therefore, a sound principal to provide vitamins from natural sources in preference to synthetic products. As vegetable ghee lacks vitamins—particularly A and D, their introduction into the product should be made compulsory by law.

FRUIT

Fruit-growing is a special art. It is so diversified and widespread in nature that in the limited space that can be allotted to it in a book on general agriculture, it is impossible to cover all aspects of it. An attempt is, therefore, made only to give important features of this industry.

Position of the fruit industry.

Fruit growing is an ancient practice and has been largely the hobby of the rich. Scientific work on this industry was started in this province in 1926, when a fruit section in the Punjab Agricultural Department was established. Since then fruit-growing has made considerable progress and most of the old pleasure gardens are giving place to commercial orchards planted on modern lines.

Area.

In 1928 the area under all kinds of fruits in regular orchards was estimated by the Fruit Section with the help of district revenue officers at 49,323 acres only. In 1933 it increased to 61,700 acres, representing an increase of about 25 per cent. over the 1928 figures. Regular annual official returns with area under fruits began to be separately recorded in the Season and Crop Reports from the year 1939-40. The figures up-to-date are given below:

Year			*Total area under fruits in acres*
1939—40	..	..	93,261
1940—41	..	..	86,199
1941—42	..	..	100,339
1942—43	..	..	95,021
1943—44	..	..	103,983
1944—45	..	..	110,396

It will be observed from these figures that the area during the last six years has varied widely from year to year. Increase in one year has usually been followed by decrease in the following year, except in the last two years when steady increase took place. The general tendency for the acreage, however, is to go up. The area in 1944-45 is nearly double the 1933 area. The latter, however, is only 0.3 per cent. of the cultivated area of the Punjab. Owing to lack of detailed statistics, area under different fruits is not available. *The marketing survey of fruits in 1935, however, revealed* the position of the main fruits as follows:

Fruit.		*Estimated area.*	*Percentage of total area.*
1. Mangoes	..	32,238	52.3
2. Citrus fruits	..	17,151	27.8
3. Stone-fruits	..	10,022	4.9
4. Pome-fruits	..	2,683	4.4
5. Others	..	6,606	10.6
Total	..	68,700	100.0

It will be observed that mangoes and citrus-fruits are by far the most important fruits grown in this province accounting for nearly 70 per cent. of the total area. Although mango trees are grown here and there, all over the province, yet their production is largely centralised in the submontane districts of Ambala, Hoshiarpur, Gurdaspur, Kangra, Karnal and the south-western districts of Multan and Muzaffargarh. Most of the area is put under seedling mangoes of the sucking type, though grafted varieties are also slowly becoming popular. In the matter of citrus fruit the province ranks third in the country, being only below Madras and C.P., which occupy first and second positions in India. The quality and type of sweet-oranges (*maltas*) grown here are, however, superior to those found in any of the other citrus-growing tracts of the country. Canal colonies, comprising the districts of Shahpur, Montgomery, Lyallpur and Sheikhupura are important for producing citrus fruits, specially, *maltas* and grape fruit.

The loose-skinned oranges or *sangtras* are mainly grown in the districts of Lahore, Hoshiarpur, Gurdaspur and Kangra. The grape fruit and lemons are of recent introduction in the Punjab, and the area under these fruits is comparatively small.

Apples are mainly grown in Kulu valley and Simla district, though a small beginning has been made in Murree hills as well. Transport, however, presents a serious difficulty in these areas. The commercial centres of production for local pears, loquats, plums and peaches are Amritsar, Lahore and Gurdaspur. Amritsar is also important for the production of guava and *phalsa* fruits.

Production.

The production and yield statistics of fruit are entirely lacking. The figures collected during the course of marketing survey of fruits in 1935, however, show that the production of various fruits is inadequate to meet the local requirements, except in the case of sweet oranges (*maltas*), grape fruits and crab-apples. For this reason enormous quantities (about 7½ lakhs maunds in 1935) of different kinds of fruits, especially bananas, mangoes, apples oranges, grapes, *sangtras*, pears, plums and apricots are imported into this province every year. Small quantities of *malta* oranges, grape fruit, crab-apples, pears and peaches are, however, exported to markets like Calcutta, Karachi, Delhi and neighbouring Punjab States during the main season. Some quantities of *sangtra* oranges, apples, grapes, pears, bananas and mangoes are also re-exported to the adjoining Punjab States and provinces after importing them from the surplus provinces. The imports, however, outweigh the exports and the province is thus deficit to the extent of 7½ *lakh maunds*. Bananas are chiefly imported from Bombay, Madras and C.P., apples and pears from Kashmir State, *sangtra* oranges from C.P., Bombay, N.-W.F.P. and Patiala State, the first being the most important of all; grapes and apricots from Baluchistan and N.-W.F. Province and plums from N.-W.F.P. and Kashmir.

The production, imports, exports and net available supply for this province for the year 1934-35 is tabulated below:

Kind of fruit	Estimated production	Imports	Exports and re-exports.	Net imports (+) or exports (—)	Net available supply for consumption
	Mds.	*Mds.*	*Mds.*	*Mds.*	*Mds.*
Mangoes ..	2,356,872	239,413	58,027	(+)181,386	2,538,258
Apples ..	31,855	166,681	90,432	(+)76,249	108,104
Pears ..	271,967	73,235	30,064	(+)43,171	315,138
Loquats ..	104,702	3,637	200	(+)3,437	108,139
Crab-apples ..	31,520	535	4,157	(—)3,622	27,898
Plums ..	69,017	18,123	1,522	(+)16,601	85,618
Peaches ..	324,660	9,891	3,367	(+) 6,524	331,184
Maltas ..	524,256	3,620	15,772	(—) 12,152	512,104
Sangtras ..	711,271	86,377	20,297	(+)66,080	777,351
Sweet Limes ..	136,811	2,815	978	(+) 1,837	138,648
Limes ..	100,991	5,922	284	(+) 5,638	106,629
Bananas ..	1,160	307,593	7,311	(+) 300,282	301,422
Grapes ..	2,877	67,729	5,473	(+) 62,256	65,133
Apricots ..	..	10,660	..	(+)10,660	10,660
Grape fruit ..	4,128	10	625	(—) 615	3,513
Citron ..	85,464	..	..	..	85,464
Cherries ..	81	500	120	+380	461
Total ..	4,757,632	996,741	238,629	+758,112	5,515,744

On the basis of these figures per capita consumption in this province compares with that of the United Kingdom as follows:

Kind of fruit	Per capita consumption (in pounds) Punjab 1934-35	United Kingdom 1925
Apples	0.37	31.1
Pears	1.09	1.7
Plums	0.27	3.4
Citrus fruits	3.50	27.0
Peaches	1.30	..
Grapes	0.25	..
Bananas	1.04	..
Loquats	0.37	..
Apricots	0.05	..
Crab apples	0.08	..
Cherries	0.001	1.3
Currants	..	0.9
Strawberries	..	2.1
Gooseberries	..	1.7
Mangoes	8.10	..
Total	16·421	69.2

From these figures it is evident that the per capita consumption in United Kingdom is more than four times that of this province. Although during the last decade area under fruit has gone up by about 50 per cent. yet per capita consumption has not increased in the same proportion because the population has also increased by about 20 per cent. If we base our present consumption on 1935 trade figures the per capita consumption would not be more than 20½ pounds. Even in the case of citrus for which this province is surplus, the per capita consumption is very low in comparison with other citrus-producing countries of the world as is clear from the following figures:

Country	*Per capita consumption in pounds*
Palestine	222
Spain	85
U.S.A.	54.3
Brazil	53.9
Egypt	30.7
Italy	23.9
Japan	15.0
Union of S. Africa	10.4
India	3.2
Punjab	3.5

The low figures of per capita consumption of various fruits suggest that the production should increase considerably, so as to bring the fruits within easy reach of the general, population. In a well-balanced diet, an adult requires daily two ounces of fruit.* On this basis the total requirements of fruits work out to 15 million *maunds*. To make provision for this 1,50,000 additional acres are required. In other words the present area should be increased by 150 per cent.

Establishing of orchards.

Fruit-growing being a long term investment owing to the life of trees being somewhat long, careful planning of the garden is very essential. The mistakes committed in planning not only prove a net economic loss to the grower, but are costly to rectify in later stages. Some of the points which should be considered when planning a garden are given below:

Climate and Soil

According to climatic requirements fruits can be divided into two classes; (1) those which can be grown under temperate conditions, such as apples, pears, peaches, plums, apricots, etc., and (2) those which can be grown under tropical conditions, such as citrus fruits,

* "Health Bulletin," No. 23, page 14.

mangoes, loquats, dates, guava, figs, bananas, lichis, custard apple, papaya, pine-apple, pomegranate, jujube.

Since the roots of fruit trees go deep in the soil, the nature and character of sub-soil are of special importance and must be examined before the trees are planted. This can be done by digging holes at random at different places of the field to a depth of 6 to 8 feet. Sub-soil underlaid by gravel, course sand, hard pan of clay or other impervious strata and alkaline are unsuitable for fruit growing. Swampy and water-logged soils should also be avoided. Water table within 6 to 10 feet range of root growth, especially if it varies in depth according to season, is also undesirable.

The soil requirements of various fruit trees are somewhat as follows:

	Kind of fruit.	*Soil requirements.*
1	Mango and Haman	Deep, well-drained loamy soil retentive of moisture.
2.	Citrus fruit ..	Deep, well-drained sandy loam with good amount of organic matter.
3.	Pears ..	Can grow on a variety of soils, but usually clay loams are preferred : on sandy loam soils trees are apt to make rapid growth aud are short-lived.
4.	Loquats ..	Good, well-drained right loam soil.
5.	Apple ..	Deep rich, well-drained calcareous loamy soil.
6.	Peach ..	Varying with stock used for budding, peach stock would do well on light warm sandy loam soils while plum stock may thrive on heavy and moist soils.
7.	Guava ..	Deep sandy loam.
8.	Almond ..	Well-drained, dry light, but warm soil with good depth is preferred.
9.	Apricot and plum.	Varying with the stock used. For peach stock light, dry, warm sandy loam soils are required while apricot

		stock can stand heavier and moist soils as compared with peach. Plum stock can tolerate even heavier soils than the apricot stock.
10.	Grapes	.. Sandy loam soil not retentive of too much moisture preferred.
11.	Pomegranate	.. Deep calcareous soil.
12.	Fig	.. Any well-drained soil.
13.	Date	.. Sandy to thick clay, can stand considerable accumulation of alkali in the soil.
14.	Cherries	.. Deep sandy loam soil of alluvial nature.
15.	Strawberry	.. Sandy loam, but rich in organic matter.
16.	Papaya	.. Sandy loam to loam preferred.

Site. Great care should be exercised in selecting the site for an orchard. The following points may be taken into consideration with advantage:

1. A careful study of the place should be made before planting the garden. Areas, where fruits are not being grown or have not been tried or where their cultivation has been discontinued, are open to considerable risk.

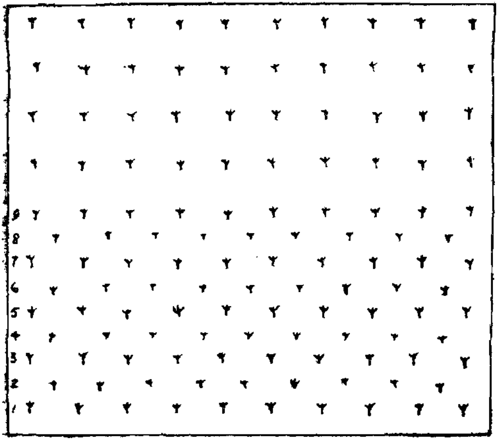
2. The site should preferably be in a section where fruits are already grown, as this would be helpful in the sale of the produce. Moreover, it would reduce the risk of theft, which is common in isolated orchards. However, where planting is to be done on a large scale the sectional preference can be overlooked.

3. The site should be as near the market as possible.

4. The garden should be near a good metalled road or railway station to facilitate transport to markets.

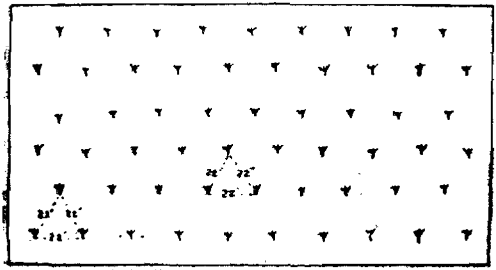
5. A post office, within easy reach, is always an additional blessing.

6. Good irrigation facilities are essential for successful production of fruits.



LAY OUT OF GARDEN.

Half area (*i.e.* upper part) under SQUARE SYSTEM.
Half area (*i.e.* lower part) under BUINCUNX SYSTEM.
Trees are 22 ft. apart in SQUARE SYSTEM.
Rows 1, 3, 5, 7, 9 are permanent fruit trees while rows 2, 4, 6, 8 are fillers i.e. temporary trees.



EQUILATERAL OR HEXAGONAL SYSTEM

Fig. 28.

The land which, is already under the farm crops needs no special preparation. In the case of newly-opened land, especially wooded with trees, it is exceedingly important to prepare the land thoroughly before laying out the orchards. The old trees should be dug out by the roots to a depth of several feet, ensuring that all the large roots are removed. After clearing the land, it should be levelled to facilitate irrigation. It should then be prepared thoroughly by ploughing and cross ploughing and brought to a fine tilth which may be improved by growing and burying leguminous crops should the soil be poor.

Preparation of land.

There are three common methods of planting the orchards.

Method of planting

These are: (*a*) A square or rectangular system,

(*b*) quincunx, and

(*c*) equilateral or hexagonal; as shown in the diagram (Figure 29 page 345).

Square or rectangular system is most commonly used, though the choice depends upon the nature and kind of fruit to be grown. The main draw-back of the system is that trees cannot be equidistant from each other in all directions, a portion of the soil in the centre of the square or rectangle remains unused. This system is recommended when the distance between the trees is 20 feet or less.

Quincunx system is designed to overcome the defect in square system by planting a fifth tree in the centre of the square. This system is useful in cases, where short-lived trees like peaches, grapes, or guavas are planted temporarily (as fillers), among the trees occupying the field permanently. The fillers of course should be removed as soon as they are found to be interfering with the growth of permanent fruit trees.

In the equilateral or hexagonal system the trees are equidistant from each other in every direction and about 15 per cent. more trees are planted on the same land than by square system. The following table shows the number of trees that can be planted per acre at various distances by square or hexagonal system:—

Distance between rows of trees (in feet)	System of planting and No. of trees per acre.	
	Square system (trees)	Hexagonal system (trees)
10	435	500
12	302	347
15	193	222
18	134	154
20	109	125
22	90	103
25	69	80
30	48	54
35	35	40
40	27	31

The distances for planting various kinds of fruit trees depend upon the available moisture supply and growing habits of particular species of variety. Stocks upon which proper kinds of fruit trees are budded also play an important part. For instance *mohri* and *mitha* stocks have a dwarfing effect on *maltas*, grape fruits and *sangtras*, while *kharna khata* stock has an outstanding character of invigorating these fruits. However, the following distances would serve as a rough guide to the fruit growers:—

	Kind of fruit	*Distance in feet*
1.	Apple, apricot and cherry	20 to 25
2.	Banana, grape and papaya	10
3.	*Malta*	18 to 20
4.	*Sangtra*, pear, guava, sweet lemon, lime & plums	20 to 25
5.	Dates	15 to 20
6.	Jaman, *ber* seedlings, jujube	30 to 35
7.	Mango seedling, figs & walnuts	35 to 40
8.	Pomegranate	15
9.	Mango grafted	30
10.	*Litchi* & *loquats*	25
11.	Peach	20
12.	Mulberry	25 to 30

Selection of plants

The selection of the right type of plants and the right varieties is the foundation of successful gardening. The high-yielding varieties of known parentage, which have proved a success under local conditions and for which there is a demand in the market, should be selected for planting. If there is no local or nearby market, it may not be desirable to grow soft fruits like *loquats*, peaches and strawberries which cannot stand shipment over long distances. Citrus fruits, apples, pears, walnuts, etc. would not do well under such circumstances. The plants should be purchased from a reliable nurseryman, near to the place of planting, avoid damages in transit and subsequent mortality in the garden. The plants should be vigorous, well-shaped and uniform in size. Medium-sized plants of one year age, budded or grafted at about a height of 12 inches from the ground level are considered best.

There are two distinct seasons of planting fruit trees in this Province.

Planting.

1. Spring.—From the end of January to the middle of March.

2. Monsoon.—Middle of July to the end of September.

The latter is suitable for planting evergreen plants like citrus fruit trees and mangoes, while the former is considered best for planting both evergreen and deciduous trees (peaches, plums, apples, apricots, cherries, pears and grapes) which shed their leaves in winter. There is less mortality among plants, planted in spring as compared to August, September.

After the laying out of the orchard, well before the plants are to be set in the field, round pits with three feet diameter should be dug at proper places. The size of the pits would, however, depend upon the nature of the soil, the rule being that harder the soil the bigger the pits. They should be allowed to remain open for a week or ten days, and then filled with silt and well decayed farmyard manure with which the top foot soil taken out of the pit is mixed, so as to allow a crown of 4 inches above the soil surface. Soon after filling, the field should be irrigated. The plants should be set in with the help of a planting-board after the soil is in a workable (*wattar*) condition. It is important to set the plants at precisely the same height, as they were in the nursery. The soil around the plant must always be well-pressed, so as to enable the plant to come in firm contact with the soil to stand heavy winds. After setting the trees, irrigation should be given.

It is customary with progressive nurserymen to cut back the deciduous trees like peaches, plums, apricots, apples, pears etc., to a height of 18 to 24 inches, and the grape vines to about 6 inches, to regulate the shape and to compensate for the loss of roots. In case it is not done before planting, it should be carried out immediately after the plants have been set in the field. A citrus fruit plant requires comparatively less heading back. The grafted mango-plants raised in pots require no heading back, the planting being done without disturbing the root system. The system of raising grafted mango-plants in pots, however, is tedious and uneconomical, involving risks of death of plants in transit, as also after planting in the field. To avoid these difficulties, the newly-discovered method of budding *in situ* may be followed with advantage. According to this system the stones of heavy-yielding seeding mangoes or seedlings raised from them may be planted 30 feet apart in permanent places. To ensure germination, there should be two stones in one pit. When the plants are about 3 years old they should be budded over with desirable grafted variety by 'T' or Shield method, ordinarily followed in the case of citrus fruit plants. Care should be taken that the bud is secured from the stock which is equal in thickness and age to that of the shoot to be budded. The unbudded shoots of the seedling stock should be removed from the point of origin and only the scion shoots should be allowed to grow.

For the first one or two years, it is desirable to protect the evergreen fruit trees like mangoes, citrus fruits, *lichis* etc., from sun and frost. Whitewashing the trunks is a good device to save the plants from sun. Forty pounds of slaked lime in about 12 gallons of hot water diluted, if necessary, with cold water, to secure easy flow would make ideal whitewash. For protection against frost, temporary thatching may be erected all round the plant from the ground to a foot or two above the plant head.

Irrigation.

The number of irrigations would depend upon the amount of rainfall, type of soil, other climatic conditions and the age and kind of fruit trees. Generally speaking, deciduous fruits require about 30 inches of rainfall or irrigation. The citrus fruit trees being evergreen require larger amount of water, 35 inches to 40 inches. Since the rainfall in the plains of the Punjab is comparatively low, artificial irrigation is necessary for the successful growth of fruit trees. In submontane districts the trees require less irrigation water than in other districts.

After the plants are set and first irrigation given, basins about two feet wide and three inches deep at the exterior boundary with an upward slope towards the trunk should be made around the plants to facilitate irrigation. These basins will, therefore, be about 4 feet in diameter. The basins may be connected by a subsidiary water channel running in between the rows of trees. The second irrigation may preferably be given a day or two after the first one and thereafter at intervals of a week or ten days in summer and about two to three weeks in winter. The size of basins is increased with the increase in the spread of the trees. This system of irrigation may be adopted for the first four to five years, but later on, flood system may be followed as the feeding root zone extends far away from the base of the trees.

Manuring.

For the proper growth and production of crop, the fruit trees must be supplied with adequate plant food. Often it has been noticed that orchards become unprofitable after reaching the age of 10 to 15 years for want of adequate nourishment. In order to avoid this, the fertility of the soil should be maintained, by the application of farmyard manure and artificial fertilisers. In actual practice, the necessity for the application of manure and fertilisers will not be felt till after the first year of planting.

Varieties recommended.

The varieties of important fruits which are recommended by the Punjab Agricultural Department, are given below :—

Citrus. (1) *Malta.*

(*i*) Excellencis,
(*ii*) Vaniella,
(*iii*) Musambi,
(*iv*) Seville,
(*v*) Pineapple,
(*vi*) Valencia late,
(*vii*) Dulcis,
(*viii*) Jaffa, and
(*ix*) Blood red.

(2) Grape-fruit

(*i*) Marsh's seedless,
(*ii*) Foster, and
(*iii*) Duncan.

(3) Lemons.
(*i*) Eureka.
(*ii*) Villa Franca.

Mangoes. (*i*) *Langra.*
(*ii*) *Dusehri.*

Apples (*i*) Cox's Orange Pippin.
(*ii*) Newton Pippin.
(*iii*) American Mother.
(*iv*) Blenheim Orange.
(*v*) Red Delicious.
(*vi*) Baldwin.
(*vii*) Golden Delicious.
(*viii*) Stamford Pippin.
(*ix*) Autumn King Pippin, or King of Pippin.
(*x*) Granny Smith.

Pears. Williams

Dates. (*i*) *Hillawi*, and
(*ii*) *Khudrawi.*

Date-palm (Phœnix dactylifera.)

The natural habitat of the date-palm is the vicinity of water supply in a dry-parched desert with scorching summer heat. Though acclimatized to intense heat, yet it is able to bear moderate cold. An extremely dry atmosphere, high temperature and plenty of water, are, therefore, essential for its sucessful cultivation. Rains during the fruiting period affect both the quality and quantity of fruit. A locality subject to excessive rains during this period, therefore, is unsuitable for date-palm cultivation. Practically any soil on which ordinary farm crops can be grown is suitable for this tree, but sandy loams are the best.

Although date-palm trees are found growing here and there in almost every district in the plains of the province yet the production is centralised in the riverain tracts of Muzaffargarh, Dera Ghazi Khan, Multan, and Jhang districts. Some plantations also exist in Lahore and Shahpur districts. Throughout the province, mostly inferior varieties grown from seeds instead of suckers are met with.

The total number of date-palm trees for the entire province is not known. In the important date-palm-growing districts of Muzaffargarh, Dera Ghazi Khan, Multan and Jhang the number of trees is about 4 millions. Of this, only about $1\frac{3}{4}$ million trees bear fruit, as shown below :—

District		No. of trees in thousands (1937).		
		Bearing	Non-bearing (Including male trees)	Total
Muzaffargarh	..	794	625	1,419
Dera Ghazi Khan	..	411	866	1,277
Multan	..	372	493	865
Jhang	..	164	215	379
Total	..	1,741	2,199	3,940

No accurate information regarding yield is available. A full-grown tree yields from 10 to 40 *seers* of fruit. Taking 20 *seers* as the average yield per tree, the total production of dates in the province works out to 870,000 *maunds* in a year. Apart from local production, dates are also imported from Persia, etc. Before the war, the value of these imports aggregated to over half a *crore* of rupees. There is thus a great scope for the extension and improvement of date-palm cultivation in the Punjab.

The trees should be raised from suckers instead of seed which may be planted either in September or in February. Each sucker should preferably weigh about 3 *seers* because *offshoots weighing less than this are apt to die when transplanted.* The leaves should be trimmed before suckers are detached from the parent trees. Three to four years old suckers are most suitable for planting. The suckers may be set in a field from 15 to 20 feet apart. Manuring of the suckers at the time of planting is inadvisable and may preferably be deferred till they are well-established in the soil and have started new growth. A moderate quantity of well-rotten farmyard manure spread round the plant and mixed with the soil would give favourable results. To the full grown trees, about 25 *seers* of manure may be applied every year.

The suckers should be irrigated soon after planting, taking care, however, that irrigation water does not enter the crown of the sucker for if this happens the sucker will die, on account of the decay of the terminal bud. As a matter of fact, water should not come in direct contact with the sucker.

For the first 40 days after planting, the suckers may be watered daily and in the next 40 days the water may be given after every 2 days. After growth has started the irrigation may be done after every 4 to 5 days, depending upon the rain, character of soil, climate etc.

The trees of Basrah varieties generally bear fruit in the fourth year after transplanting, but since they are also producing suckers, the fruits generally shrivel. At the fruiting time, therefore, the plants should be well-manured with farmyard manure and supplied with sufficient water.

With a view to improving the date culture in this province, the Punjab Agricultural Department imported several varieties of dates from Mesopotamia in 1910. Since then suckers of these varieties are being supplied to the public at a nominal cost. There are, however, two handicaps : (*i*) the date-palm trees are raised from suckers which the parent trees produce only for the first 5 to 20 years of their life, and (2) the principal date-growing countries of the world have prohibited the export of suckers of high quality varieties. These factors have, therefore, been responsible for the slow progress. However, about 15,000 suckers of *Hillawi* and *Khudrawi* varieties, which have given promising results both in respect of quality and yield, have recently been imported from Persia and planted at the Jhang Agricultural Farm for further multiplication. In due course, suckers of these varieties will be distributed on a large scale. The average yield of these varieties under Lyallpur conditions is about 32 *seers*, though some trees have yielded as much as 149 *seers* of fruit. Taking the average yield under field conditions to be only about 20 *seers*, a gross income of Rs. 2,000 can be expected from an acre planted under the date-palm trees. By equilateral triangle system, 192 trees can be planted in an acre, which would yield about 100 *maunds* of *doka* fruits. The average price of this fruit may be taken to be Rs. 20 per *maund*.

From the second year onwards, the fruit-trees require regular application of manures and fertilisers. From second to third year about 10 *seers* of well-decayed farmyard manure or a quarter pound of ammonium sulphate or Nitrate of Soda may be applied to each plant, during the latter half of January. From fourth year to sixth year the dose of farmyard manure may be increased to 30 *seers*, and that of the artificial fertilisers to one pound. Thereafter one to $1\frac{1}{4}$ maunds of farmyard manure or $1\frac{1}{2}$ to 2 pounds of ammonium sulphate or soda nitrate per tree should be applied every year. The ammonium sulphate may be applied three weeks before blossoming, while nitrate of soda may be applied 15 days before this period. Farmyard manure should be worked well in the soil by means of spade, taking care that no manure is applied to the $1\frac{1}{2}$ feet soil round the trunk of the trees.

Insect pests.

There are a number of pests which attack fruit plants. The important ones which attack the citrus fruit trees in the Punjab are white fly, citrus psylla, leaf minor, leaf butterfly and scale insects.

The white flies suck the cell sap of leaves, fruits and shoots and lower the vitality of the tree. To prevent the attack, it is desirable to give proper spacing to the trees and do away with the citrus hedges which serve as a breeding place, spraying with rosin compound (1:5) during September effectively controls this pest.

Citrus psylla is a small-sized winged insect which rests on the underside of leaves and branches. It can also be controlled by spraying the trees with rosin compound (1 : 5) and tobacco decoction (1 : 6) during February and March.

The leaf minor feeds on the cell sap after entering the tissues of the leaves. The attack starts in February and becomes very severe in March to May and September to November. It can be controlled by spraying the plants thrice at intervals of 10 to 14 days with tobacco decoction during April-May or September-October.

The scale insects and mealy bugs attack all parts of the trees and feed on the sap of the leaves, twigs, fruit, trunks etc. Oil emulsion (1 : 40) sprayed during September to February is an effective remedy for the red scale.

The most common and destructive insects of the mango tree are mango hopper and mango mealy bug. These cause damage by sucking the juice. They mostly attack flowering stalks and terminal portions of tender shoots, which wither and dry and the fruit does not set. Rosin wash and crude oil emulsion should be sprayed in winter during morning hours. Mango mealy bug can be controlled by banding the trees in the end of December with cotton-wool or *san* hemp rope or thick *munj* rope soaked in a mixture prepared from equal amount of coaltar and crude oil emulsion or in rosin dissolved in rapeseed oil (3 : 1). The band is put round the trunk of the tree 3 to 4 feet above the ground and is about 9 inches thick. It should be kept on the tree till the end of May. The nymphs and females collected on these bands should be killed by brushing them into a vessel containing water with a film of kerosene oil on the surface. The rubbish and scrapings underneath the trees should be completely destroyed, and the top 4″—6″ soil should be scraped off to destroy the eggs. The heavily infested trees should be sprayed with fish oil rosin soap prepared by dissolving 12 *chhataks* of the soap in four gallons of water.

In Simla hills and Kulu Valley, San Jose scale is a serious pest of apples, pears, plums, apricots, walnuts, cherries and peach trees. It lives on the sap of the host plant which in many cases may dry up. It may attack fruits as well, thus rendering it unmarketable. The insect is spread through infected nursery plants bud or graft wood. To prevent further spreading, it is, therefore, desirable to fumigate the nursery stock. It can be controlled by spraying the infested plants with lime sulphur emulsion or diesel oil emulsion during winter season.

There are numerous diseases of fruit trees. For want of space only a brief reference to the diseases which damage citrus fruit trees, apples etc., is made here. The common diseases of citrus fruit plants are citrus wither-tip, citrus canker, citrus wilt and alternaria rot of citrus fruits.

Diseases

Citrus Wither Tip is more common in *maltas*, *sangtras* and Limes. It is a fungus disease and attacks leaves, branches, flowers, flower buds and fruits. Withering of the tips of young shoots is a characteristic symptom of this disease. If the attack is very severe the entire tree may be killed. Weak plants are more susceptible to this disease. It can be controlled by regular pruning of trees every year and spraying the trees with Bordeaux mixture (5 : 5 : 5) compound or preferably rosin Bordeaux mixture after pruning in January-February before blossoms appear on the buds. Second spraying may be done in August. Manuring and intercropping the garden with leguminous crops also helps in building up tbe vitality of the plants.

Citrus Canker is a very common disease in this Province. It is a bacterial disease caused by the ***Pseudomonas Citri*** and attacks leaves, twigs and fruits. The affected fruits may drop prematurely and spoil the appearance, thus lowering their marketable value. It can be controlled by spraying the trees with Bordeaux mixture (5 : 5 : 5) or preferably Bordeaux rosin mixture thrice a year, first from January to middle of February, second in July and third in September.

Citrus Wilt is caused by ***Fusarium cœrulum*** and is particularly harmful to young stock in the nursery. The organism attacks the roots of seedlings, causing drooping down of uppermost leaves which finally turn dark brown. Gradually, the lower leaves are also involved, thus resulting in the death of the plant seedling. The disease may be controlled by treating the nursery beds with Bordeaux mixture (2 : 2 : 5) and growing of shady plants like ***Jantar*** along the beds to keep the temperature of the soil down. The seeds for raising the seedlings should also be sterilised with formalin (1 : 320).

The *Alternaria Rot* of citrus fruits is caused by "Alternaria Citri" and mainly attacks fruits. The attacked fruits break open with slightest pressure, though the fruit may appear sound in appearance. The lack of moisture in the soil or air, high temperature, age of fruit, sun and frost injury, which affect the condition of fruit tissue favour the development of the disease. For controlling the disease, the trees should be sprayed with Bordeaux mixture (5 : 5 : 50) in September and the diseased fruit should be buried deep. Holding of fruits too long on the trees should also be avoided.

The most common disease of apple trees are Scab, Powdry Mildew and Brown Rot.

Scab mainly attacks the fruits though leaves and young wood may also be involved. The badly-affected leaves dry and fall prematurely resulting in the loss of vigour of trees and reduced yield. Bordeaux mixture (4 : 4 : 50) and lime sulphur are effective sprays. The spraying should be done thrice, first before the buds open, second after the fall of petals and third about three weeks later.

Mildew attacks both leaves and flowers. It can be controlled by pruning and spraying the trees with lime sulphur solution (1 : 19), shortly after the blossoms set. In spring and summer again the affected shoots should be removed and burnt.

Brown Rot is responsible for soft brown patches on the fruit. The infected fruit in a severe case may shrink in size and drop from the tree. The infected fruits from the trees lying about in the garden should be removed and buried deep. The infected branches should also be cut away and burnt.

VEGETABLES

Area The total area under vegetables during 1941-42 was about three *lakhs* of acres. Since then there has been some decrease. Most of the vegetable area is irrigated and a comparatively small proportion is unirrigated. The important districts growing vegetables are Ambala, Hoshiarpur, Ferozepur, Lahore, Jullundur, Amritsar, Gurdaspur, Sialkot and Multan.

Vegetables are generally grown in the immediate vicinity of cities and large towns to save transport and affect early delivery, as there is a ready market for the produce at hand. In the case of early vegetables which are produced in large quantities in Ambala, Jullundur and Sialkot the vegetables are transported by means of motor lorries and railways even to a distance of 200 to 300 miles. Vegetables produced in Multan are at times sent as far as Lahore and Rawalpindi. Often the sewage water of a city is used for the production of these vegetables, and the vegetables may thus sometimes constitute a real danger to the health of the consumer. In some municipalities, however, salad crops, such as lettuce, celery, onion, beet, etc., which are taken raw, are not allowed to be grown, owing to danger of typhus infection. If, however, sullage water is properly treated there is no danger of infection from its use.

Seed Supply

The supply of good dependable seed is very essential for successful vegetable growing. The seed should be viable, clean, free from disease and insect injury, and true to its name and kind. The Government must, therefore, for the present, arrange for seed control laboratories, where the seeds could be tested for viability and purity. Suitable laws should also be passed in order to protect the grower.

The life of Seed

The limit of time for which seeds may be stored without losing their germination power varies with the kind of vegetable. Seeds of cucumber, musk melon and lettuce retain their viability longer than that of carrot, onion and celery. Climate also plays an important part. In tropical and sub-tropical countries due to high temperature coupled with high humidity seeds kept under ordinary conditions lose their viability much faster than they would do in temperate regions. The best way to store vegetable seeds, therefore, is to keep them in cold store or to put them in sealed earthen pots or stoppered jars, or in boxes sealed with paraffin and a package of fused calcium chloride or lump of quick lime to keep it dry.

Seed production

As most of the common vegetable crops are normally cross-pollinated, it is not very easy to produce pure vegetable seeds. It is, therefore, advisable for small growers particularly, to purchase their seed requirements from a reliable seed firm rather than to produce themselves. There is no difficulty in the production of seed from the common vegetables in the plains, but some of the vegetables such as cabbage, kohl rabi, English carrot and English turnip do not mature their seeds in the plains. The seeds of these vegetables, therefore, used to be imported in the pre-war days, from Europe and America. Due to transportation difficulties during the war these imports were stopped during 1942, 1943 and 1944 and arrangements were, therefore, made for their production in hilly tracts like Kashmir, Quetta, and Kulu valley at an elevation of about 5,000 feet. For the purposes of seed production these vegetables should be sown in July and August and the full-grown plants taken up for transplanting during November-December. Seed is ready for harvest next June-July. Insect pests are very harmful and in order to achieve success it is necessary to control them completely. Aphids and butterfly caterpillars are the most dangerous and should be controlled by spraying with a soap solution and picking by hand respectively. The stock seeds for multiplication and for the production of vegetables can be had from the Vegetable Specialist, Punjab Agricultural College, Lyallpur and also from various Deputy Directors of Agriculture.

CAULIFLOWER

Natural order—*Cruciferae.*
Botanical name—*Brassica oleracea.*
Var.—*Botrytis.*
Vernacular Name—*Phul Gobhi.*

Medium and heavy soils are most suitable for Cauliflower growing. Of all the vegetable crops, cauliflower and cabbage require most manuring. Experience has shown that the lack of nitrogen limits the growth of the cauliflower plant. It is, therefore, advisable to apply ammonium sulphate at the rate of 2 *maunds* per acre as a top dressing. The seed rate per acre varies from ¼ to ½ pound, according to the time of sowing, in one to two *marlas* of land. For early sowing greater quantity of seed is required due to high mortality rate of seedlings. The sowings made during September do well. The seed is sown, broadcast and covered with fine soil or decayed leaf mould, and watered with a sprinkling can. Shade should be provided to early sowings for a few hours during the hottest part of the day. They should also be protected with a covering device during heavy rains. The seedlings are ready for transplanting in about six weeks' time. The seedlings are planted on both sides of raised beds which are 2 feet wide and 2 feet apart at a distance of 1'—1½' feet from plant to plant. In the early stage cauliflower requires irrigation every week, but later on every two weeks will be enough. Thorough tillage should be given to keep down the weeds, and plants should be earthed up about 4 to 5 weeks after transplanting. It is ready for harvest when the heads have attained the proper size and are at right stage of maturity. It is available for the market from November to March according to the variety grown. The choice of a variety is very important for successful cauliflower production. Early varieties if grown late will head prematurely, and produce small heads when still young. Late varieties if sown early do not produce good big heads. A few good varieties, such as C. F. 26 and C.F.21 have been selected at the Lyallpur Agricultural Research Institute and their seeds are available for sale at Rs. 24 per *seer*. *An acre of cauliflower yields about* 5,000 heads or 2½ *maunds* of seed with an income of about Rs. 1,000.

CABBAGE

Natural Order—*Cruciferea.*
Botanical name—*Brassica oleracea.*
Var.—*Bullata Capitata.*
Vernacular Name—*Band Gobhi.*

This is a very popular vegetable with the European community though Indians do not seem to relish it and prefer cauliflower. The soil and manurial requirements are the same as for cauliflower. One pound of seed is sufficient to produce seedlings for an acre. The seedlings are transplanted *from the beginning of March to the end of July* in the hills and during September and October in the plains. Small varieties are spaced about 15 inches from plant to plant and 1½ feet from row to row, whereas the large varieties may be spaced 18 inches from plant to plant and 2 feet from row to row. There are several varieties of cabbage, the seed of which is imported from Europe and America. The most important of these are Dwarf, Early Whites, Dwarf Savoys, Large Late Drumheads and Red Cabbage.

KNOL KHOL OR KOHL RABI

Natural Order—*Cruciferae.*
Botanical Name—*Brassica oleracea.*
Var.—*Gongylodes or Caulorapa.*
Vernacular Name—*Gandh Gobhi.*

It is a cool season crop and thrives on rich soils. It responds well to liberal application of manure. It requires the same cultural treatment as that for cauliflower, Brussel's sprouts and cabbage. The distance between the rows is 18″ and between plants 9″. About 3 pounds of seed are sufficient for an acre. Kohl Rabi is harvested when the fleshy stem is about 2½″ to 3″ in diameter. If it is allowed to grow large it becomes woody.

BRUSSEL'S SPROUTS

Natural Order—*Cruciferae*
Botanical name—*Brassica oleracea.*
Var—*Gemenifera.*
Vernacular Name—*Guncha Gobhi.*

In the plains it is sown from September to the end of October. Its soil requirements and manuring are just like cabbage. The seed is sown in a well-prepared nursery bed. Twelve ounces. of seed will give sufficient seedlings to plant an acre. This is sown in 3 *marlas* of land by broadcasting and covering with ⅛″ of fine soil. When plants are 5″ to 6″ high they should be planted in fields in rows 2′ apart and 18″ from plant to plant. When plants are half grown earthing up should be done. Irrigation is required every 8 to 10 days. It produces heads after about 3 months.

BROCCOLI

Natural Order—*Cruciferae.*
Botanical name—*Brassica oleracea.*
Var.—*Botrytis or Italica.*
Vernacular Name—*Sabaz Gobhi.*

It is merely a late variety of cauliflower which produces heads in Spring. It should be sown late in October-November because it cannot stand hot weather. The cultural requirements are essentially the same as those for the ordinary cauliflower. Green sprouting broccoli have been grown at Lyallpur for the last few years. The plant produces a head somewhat similar to the cauliflower except that it is green. After the removal of the central head the plant produces small heads on the side shoots. Thus the heads are available continuously for home use or the market for several weeks.

PEAS

Natural Order—*Leguminosae.*
Botanical Name—*Pisum sativum.*
Vernacular Name—*Matar.*

The garden pea is an important vegetable crop in the Punjab. In plains and lower hills peas are sown in October and November and grow during winter months while in the hills peas are sown from the middle of March to the end of May, and grow during the summer. Peas can be grown on a variety of soils from light sandy loams to heavy clays, but it gives higher yield on heavier types of soils. Manure is usually applied to the preceding crop, but there is no harm in applying, directly, if the manure is thoroughly decomposed.

Peas are sown on raised beds, 2½ to 5 feet wide with furrows between them for irrigation. The seeds are sown near the edge of the bed about one inch deep. For tall varieties the bed should not be less than five feet and that for dwarf 2½ feet. About 20—24 *seers* of seed is sufficient to plant an acre. The seed should be sown 1 to 1½ inch apart in the rows and irrigation applied immediately after sowing. When the plants are about six inches high the tall-growing variety should be staked with tree branches or cotton sticks. A single row of sticks fixed in the middle of a bed will support both the rows of each bed. The plant should be helped towards the stakes and induced to grow away from the irrigation furrows by placing earth around the plants. Peas grown for home use as well as for the market are picked by hand. Picking should be done when the pods are well filled with young tender peas. In order to have a regular supply of peas during the season early, medium and late varieties have been separated at the Lyallpur Agricultural Research Institute, and are available for sale to the public.

The following varieties are recommended:

P.I.D.—This is an early selection from a country variety of dwarf pea, grown locally in Hoshiarpur. It can be sown in the first week of September and is ready for consumption after about one month and a half. It yields 30—40 *maunds* of green pods per acre.

P. 8.—This is also an early type taking about two months to mature. Its seed was originally obtained from U.S.A. It yields 80 to 100 *maunds* of pods per acre and is the heaviest yielder amongst the early varieties.

P. 35.—This is a mid-season variety and takes about a little over three months to mature. This was also originally obtained from U.S.A. It yields 90 to 110 *maunds* of pods per acre. This has been found to be excellent for canning, with a very heavy yield.

The yield from an ordinary crop is about 50 *maunds* with an income of about Rs. 350. When matured for seed its yield is about 6 *maunds* per acre. At the rate of Rs. 2-8 per seer, the income comes to Rs. 600 per acre.

TURNIPS.

Natural Order—*Cruciferea.*
Botanical name—*Brassica rapa.*
Vernacular Name—*Shalgham.*

Turnip is sown in the plains from the end of July to end of November. It can be grown on all types of soils, but does best on a deep rich loam. A light application of farmyard manure at the rate of 8 to 10 cartloads per acre may be made. It is preferable to sow the crop on ridges as it provides for better root development and drainage. Ridges are made 1½ feet apart and 6 to 9 inches high and the seed is sown on the top of the ridge. Irrigation is applied immediately after sowing. Seed rate is 1 to 1½ *seers* per acre for *desi* varieties and ¾ *seer* for imported varieties. Two acclimatized varieties are recommended, *viz.*, Turnips Red and Turnips White. Both of these varieties are high yielders and mild in taste. The yield per acre of fresh roots is 220 *maunds*. If matured for seed it yields 6 to 7 *maunds* per acre.

SWEDES

Natural Order.—*Cruciferae.*
Botanical Name—*Brassica napohrassice.*

This provides a much more palatable vegetable than turnips. Its cultivation is similar to turnips.

CARROTS

Natural Order—*Umbelliferea.*
Botanical Name—*Daucus carota.*
Vernacular Name—*Gajar.*

The carrot is grown in all parts of the Punjab both for forage and for human consumption. It does best in cool weather. In hills it is sown from the beginning of March to the end of May and in the plains from the middle of August to the end of November. Imported seeds should be sown in October—November. Carrot does best on well-drained loamy soils manured with farmyard manure. Fine tilth of the seed-bed is very important for carrots. Muriate of potash at the rate of 2 *maunds* per acre should also be applied in order to obtain a heavy yield. The seed rate is about 8 *seers* per acre. The carrot can be sown either on ridges 1½ feet apart or on flat. Irrigation is given immediately after sowing, followed by another irrigation after 6 to 3 days. The seedlings should be thinned to stand 2 inches to 3 inches from plant to plant. The crop should be kept clean of weeds. Watering may be done weekly when the weather is dry and fortnightly during winter. Carrots if over-watered remain watery and insipid. Towards the later period of growth the crop should be watered sparingly. The crop when grown on ridges may be harvested by pulling out the roots, but when sown on flat it has got to be dug out with a spade. Many kinds of varieties are met with, white, yellow, orange, light purple, deep purple, but orange coloured are more popular than others. Yield of fresh carrots is about 220 *maunds* per acre, and that of seed 8 to 10 *maunds*.

RADISH

Natural Order—*Cruciferea.*
Botanical Name—*Raphanus sativus.*
Vernacular Name—*Muli.*

It is an important crop grown all over the Province. It is grown for fleshy root and green pods called *moongras.* In the latter case a type of rat-tailed radish called *Soongra* is exclusively grown for its long pods. The fleshy root is taken either raw in salad form or cooked as vegetable. In the plains it is sown from the middle of June to the end of January, but the main crop is sown from beginning of September to end of October. It can be sown on all kinds of soils but loamy soils are the best. It can be sown on ridges 1½ feet apart and 9 inches high like carrots. Seed rate is 4 to 5 *seers* per acre. Irrigation is given immediately after sowing. Seed germinates in 3 to 4 days. Irrigation may be given once every week. The most important variety is a local white. Of the imported varieties, 'Scarlet gobe' and 'Icicle' have been found to be suitable for production in the plains.

BEET

Natural Order—*Chenopodiaceae.*
Botanical Name.—*Beta vulguris.*
Vernacular Name—*Chaqandar.*

It is an unimportant vegetable crop grown in the Punjab. Its sowing season is August to November in the plains. It thrives best on deep loamy soils. It is tolerant to acid soils but develops best on soils that are somewhat alkaline or saline. Seed rate is 6 *seers* per acre. It is sown 1¼" deep on ridges ½' apart and 6 to 9" high. Water is applied immediately after sowing. When plants grow about 2" tall they may be thinned 3 to 4" apart. Watering should be done every 4 to 5 days after sowing. After the crop has germinated irrigation may be given every 10 to 14 days. Early crop is ready for use in November and supply continues till end of March. Two types are met with: round rooted and long rooted. Round rooted varieties are earlier and better adapted to production on shallow soils, than long rooted ones.

ONION.

Natural Order—*Liliaceae.*
Botanical Name—*Allium cepa.*
Vernacular Name—*Piaz.*

This is a hardy crop and thrives best in relatively cool season. It is grown both for its mature and immature bulbs. The mature bulbs are used throughout the year. It is used either raw or cooked by almost all classes of people and is thus in demand throughout the year. It is considered to be appetising and healthful.

Onion is grown on almost all types of soils from sandy loam to heavy loam, but loam soils are generally preferred. It is said to tolerate a certain amount of alkalinity in the soil and can, therefore, be grown on slightly alkaline soils. The crop requires heavy manuring. About 24 cartloads of manure per acre may be applied. If there is a shortage of farmyard manure it may be supplemented with superphosphate and ammonium sulphate, at the rate of about one *maund* of each per acre.

In the plains onion seed is sown from middle of October to middle of November, and in hills from the beginning of March to the end of May for nursery seedlings. About four *seers* of seed sown in about 5 *marlas* of land is sufficient to produce seedlings for one acre. The seed is sown broadcast in a thoroughly prepared bed, which has been enriched with ample supply of well rotten farmyard manure. The seed is then covered with fine soil and water is applied with a sprinkling can, so as to soak the soil well. The irrigation should be repeated every 3rd or 4th day till the plants are well established. The seedlings are ready for transplanting in eight to ten weeks and are planted in middle of January in plains. The field, where seedlings are to be transplanted, should be divided into small plots of convenient size for irrigation and marked in rows 9 inches apart, and seedlings planted 3 to 4 inches apart in the rows. Irrigation is then applied immediately after transplanting.

Onions require steady moisture supply and irrigation should, therefore, be applied once every two weeks. When the crop is nearing maturity it may be watered sparingly. When the tops start falling over, irrigation should be stopped altogether. During the growing period two or three hoeings may be given in order to keep control over weeds.

The crop is ready for harvest about the end of May. The harvesting is done by pulling out the bulbs by hand. The yield of onions per acre is 100—150 *maunds*. As soon as the crop has been removed from the field it should be taken to a shady place and tops cut off. The onions should then be spread over the floor of a room in a thin layer, and should be left there for about a week or ten days. The onions can then be collected and stored in *kups* made of straw or *sarkanda* in an airy and shady place.

Two types of onions—white skinned and red skinned are usually grown, though at times yellow skinned are also noticed but these are not liked. The white and yellow skinned varieties are mild and of good flavour, while the red variety is more pungent, but it keeps better in storage than the white ones.

Seed Production.

For this purpose the dry bulbs of small size are selected and planted in a small bed in the end of October or November, 2 ft. row to row and 1 foot plant to plant. The large bulbs can also be used by cutting them into three or four pieces each, taking care that each piece has a portion of "Stem plate" (root zone) with it. The seed rate is about 12 *maunds* per acre. The seed is ready for harvesting in April-May. About 8 *maunds* of seed can be obtained from an acre.

The green onions or *Gandhel*, as they are called, are grown for selling in the green stage. For this purpose the small bulbs from the previous crop are planted in September-October. These are ready for consumption as green onions in about four to five weeks after planting.

GARLIC.

Natural Order—*Liliaceae*.
Bot. Name—*Allium sativum*.
Vernacular Name—*Lassan*.

This is much more strongly flavoured than onions. Garlic can be grown on the same type of soil as onions but it requires richer soil than onions for best yields, and it should, therefore, be more heavily manured. It is propagated from cloves which are planted 3 to 4 inches apart in rows about 9 inches apart. It requires about 6 to 7 *maunds* of bulbs to plant an acre. The irrigation and hoeing and harvesting is just the same as in onions. It is ready for harvesting about the beginning of May.

BRINJAL OR EGG PLANT.

Natural Order—*Solonaceae*.
Bot. Name—*Solanum malongena*.
Vernacular Name—*Baingan*.

Brinjal resembles tomatoes in its cultural requirements but requires higher temperature for growth. In the plains three sowings are made during the year. First is made from middle of February to middle of March, and the seedlings put out in the field before the end of April. The Sirhindi type of egg plant is sown at this time. The second sowing is made from middle of May to middle of July. Large round purple and large long purple fruited types are grown at this time. The third sowing starts towards the end of October and the seedlings allowed to remain in the seed-bed during winter till all danger of frost is over. The seedlings are, of course, protected with a covering of straw or *sarkanda* during the period of frost, and are transplanted about the first or second week of February. Round small purple fruit types are grown at this time.

Egg plant can be grown on all kinds of soils, but does best on heavy types of soils. Well-rotten farmyard manure should be applied to the land at the rate of 20 to 25 cart-loads per acre. For raising nursery the seed is sown in the nursery bed in the same manner as in the case of tomatoes. About ½ to ¾ lb. of seed grown on about 4 to 6 *marlas* of land yields sufficient seedlings to plant an acre. Seedlings are transplanted when they are about 4″ to 5″ high. The plant should be removed from the seed-beds with earth sticking to the roots and planted in the fields in rows 3′ apart at a distance of 18″ from plant to plant. The crop is generally planted on the flat ground but may be grown on ridges or raised beds also. During hot weather irrigation should be given every week and in cool weather every two weeks. The fruit of egg plant is used in immature condition. If allowed to ripen it becomes hard and tough. The harvesting of the spring-sown crop begins in last part of May and continues till December when the plants are killed by frost. The plants are then cut back to about a foot and the stems are covered with dry grass or dry sugar-cane leaves. In spring when weather warms up, new shoots come up and bearing starts about the middle of March and continues through the rainy season. The plants should then be dug out, as the strands are thin and exhausted. The bearing of the third crop, *i.e.*, of the crop transplanted in February starts towards the end of March and continues to furnish supplies up to beginning of rains. The second sowing begins to bear fruits towards the close of rains and lasts till December.

TOMATOES.

Natural Order—*Solonaceæ.*
Bot. Name—*Lycopersicum esculentum.*
Vernacular Name—*Tamatar.*

This is a warm-season crop and does not tolerate frost. In recent years its production in the Punjab has increased considerably, and the fruit is available in the market practically all the year round. In the hills it is sown from middle of March to the middle of May, while in the plains three crops are produced, namely two early crops and one main crop. Seedlings are ready in 3—4 weeks' time. For the earliest crop sowing is done about the middle of June to the middle of July. This crop is over before frosty weather. The second early crop is grown from the middle of August to the middle of October. This crop bears twice, once in December *to March and second time in May-June.* For the third crop, the seedlings are transplanted in February and the crop gives fruit from May to the end of July.

Two ounces of seed give sufficient seedlings for one acre. Owing to high mortality in summer in case of early sowings about eight ounces of seed are usually sown to get seedlings for an acre, but for late sowings 4 to 5 ounces of seed are enough after allowing for all losses. It may be noted that *an ounce of tomato seed contains about eight to nine thousand* seeds. One *marla* of seed-bed is enough for 2 to 3 ounces of seed. For hot weather sowings it is necessary to shade the bed till the seedlings are well established. The seedlings also require protection from heavy rains. The plants are ready for transplanting when six weeks old. The seedlings are planted 2 to 2½ feet apart and 1½ to 2 feet from *plant to plant. Staking may be done when the plants are* about 9 to 12 inches high. For the winter crop the spacing is 15 to 18 inches from plant to plant and 3 to 4 feet between each row. Protection against frost by covering with grass is necessary. During the periods of frost, irrigation is recommended as it prevents the temperature from going too low, and thus the danger of frost is minimised. As fully-ripened fruit does *not stand* handling *and hauling and* quickly deteriorates it is advisable to pick the fruit just when it is turning colour, as it will then reach the consumer in better condition. For home use, however, the fruit may be allowed to ripen on the plant. Sometimes the growers pick the green fruit at the time when frost occurs and heap it up outdoors under a tree for ripening. The fruit, as it ripens, is sorted out for being sent to the market. Yield per acre is 150 *maunds.*

Varieties.—The following varieties have been selected at the Agricultural College Research Institute, Lyallpur, and the seed is available for sale to the public:

T. 13. (Large red).—It is a mid-season variety taking little over four months to mature. This is suitable for both autumn and spring crops and is fairly resistant to frost.

T. 29. (Best of all). This is also a mid-season variety taking about four months to mature.

T. 22. (Bony Best). This is also a mid-season variety taking about four months to mature. This is suitable for both autumn and spring crops, particularly the former but is very susceptible to frost.

CHILLIES OR RED PEPPER

Natural Order—*Solonaceae.*
Bot. Name—*Capsicum annum.*
Vernacular Name—*Mirch surkh.*

Chillies are grown more or less all over the Punjab but their production on extensive scale is carried on chiefly in Karnal and Rohtak districts where Panipat, Gharunda, Murthal, and Sonepat are big markets. It is grown in Jullundur and Ferozepur districts also. In the plains it is sown from the middle of March to the end of April for the production of dry chillies and in October for the production of green chillies during early summer. In the latter case the seedlings are protected from frost during winter and transplanted in February when all danger of frost is over. In the hills, chillies are sown from the middle of April to the end of May. Heavy loams are considered most suitable for obtaining high yields. The land also requires heavy manuring at the rate of about 40 cartloads of well rotten farmyard manure per acre. Care should be taken not to apply fresh manure as it attracts white ants, which is a serious pest of chillies. It is, therefore, advisable to apply manure to the previous crop instead of applying it direct. A top dressing of ammonium sulphate at the rate of $1\frac{1}{2}$ *maunds* per acre at the time of fruiting is very useful.

There are two methods of sowing :—

(1) Seeds are sown directly on tops of ridges $2\frac{1}{2}$ to 3 feet apart and about 9 inches high. When the plants are well established they are thinned 8 to 9 inches apart.

(2) Seeds are sown in the nursery in March-April at the rate of $\frac{1}{2}$ to $\frac{3}{4}$ *seer* of seed for producing seedlings for an acre.

The seedlings are ready for transplanting in May and June, and are sown in rows about $2\frac{1}{2}$ feet apart and plants in the rows 9 inches apart. Irrigation is applied immediately after transplanting. Chillies are ready for picking in the beginning of September and last till the end of December. For dry chillies, fully ripe and coloured fruits are picked and placed on the flat roofs of houses or in the open in a thin layer for drying and curing. Care should be taken not to heap up freshly-harvested crop for a long time, as the fruit is liable to rot. Yield per acre is about 40 *maunds* of fresh green chillies and 10 *maunds* of dry chillies.

There are three varieties of chillies : (1) Patna, (2) *khopra* and *kokla*, and (3) *lamba phal*. No. 1 is a late variety. Its fruit is long, thin and pungent, and possesses high keeping quality. No. 2 is rather short and thick and comparatively less pungent. It is an early variety and its yield is more than that of Patna. No. 3 is largely grown near about Smalkha. Its fruit is long and less pungent. It is also an early variety. Another variety known as *nakli patna* is also grown in the Panipat area. It is also long and thin but its colour is not so red as that of the Patna variety. Its keeping quality is also low. In Simla Hills an imported variety of pepper known as Simla *mirch* is also grown. It is used for salad and as vegetable. It is probably imported from U.S.A. and is referred to as Capsicum.

LADY'S FINGER

Natural Order—*Malvaceae.*
Bot. Name—*Hibiscus esculentus.*
Vernacular Name—*Okra or Bhindi.*

Two crops are raised in the plains, early and late. Early is sown from middle of February to middle of April and the late is sown during July. *Bhindi* thrives best on all kinds of soils provided they are well manured, four to 5 *seers* of seed per acre are required. It should be sown on ridges 2½ to 3′ apart. For continuous growth and pod formation, the crop should be irrigated after every 5th or 6th day in hot weather and every 10 to 14 days in cool season. Inter-culture is necessary four or five times to keep down weeds. Broadly speaking there are two types or varieties of this crop: early dwarf and tall. The former is preferred over the latter, as it begins to bear fruit earlier when the market prices are high. Some varieties have also been evolved at Lyallpur which bear fruit for picking 40 days after sowing, and whose pods are free from spiny hairs.

BOTTLE GOURD

Natural Order—*Cucurbitaceae.*
Bot. Name—*Lagenaria vulgaris.*
Vernacular Name—*Ghaya Kaddu.*

It is an important vegetable in the Province and is available in the market from March to November. It grows best in humid climate. It is planted from the beginning of March to middle of July in the plains and in some localities even in October for early production. The vines are protected in this case from frost by a *sarkanda* thatch. It thrives best on heavily-manured loamy soil. Four to five ploughings are necessary to prepare the land. It can be sown on raised seed beds. The seed rate is 2 *seers* per acre. During dry weather, irrigation is required every 4th to 5th day. In rainy season, it is watered less frequently. The fruit should be harvested while it is still tender. Round varieties are usually grown for the early crop and long fruited ones called *louki* for the late crop.

RED GOURD

Natural Order—*Cucurbitaceæ.*
Bot. Name—*Cucurbita maxinea.*
Vernacular Name—*Halwa Kaddu.*

It is also grown all over the province for fleshy fruit which is used as vegetable both in the immature and mature stages. It grows well in regions with comparatively lower temperature and higher humidity. Two crops are taken in the plains: early and late. Early crop is sown in the beginning of February to end of March and the late from middle of June to end of July. It can be grown on all types of well-drained and well-manured soils. It is sown on raised beds 8′ wide.

ASH GOURD OR WHITE GOURD OR WAX GOURD

Natural Order—*Cucurbitaceae.*
Bot. Name—*Benincasa cerifera.*
Vernacular Name—*Petha.*

It is commonly called *petha*. As a commercial crop it is grown in dry river beds. The immature fruit is cooked as vegetable but when ripe it is used for making sweetmeats. It prefers a warm climate. Like water-melons, two crops can be grown: early and late. Early crop is sown from the beginning of February to end of March and late from beginning of June to end of July. It does well on light sandy soils. Fruit intended for storage should be harvested after it is fully ripe. Fruit is harvested in September-October and is sold during winter.

BITTER GOURD.

Natural Order—*Cucurbitaceae.*
Bot. Name—*Momordica charantia.*
Vernacular Name—*Karela.*

It is grown almost in all parts of the province. It is sown in the plains from middle of March to end of April for early crop and from middle of June to end of July for late crop. Cultural requirements for bitter gourd are the same as detailed for *tinda*, except that soil should be given heavy application of manure in this case.

LUFFA OR SPONGE GOURD

Natural Order—*Cucurbitaceæ.*

Bot. Name—*Luffa acutingula and Luffa aegyptiaca.*

Vernacular Name—*Ghiya tori.*

The sponge gourd or *tori* is grown on a small scale in the plains for its tender fruit. Two types of *tori* are grown: *kali tori* which is club-shaped and sharply ribbed, and *ghiya tori* which is smooth and cylindrical. It thrives best in humid regions. Two crops: one early and the other late are sown. Early is sown from middle of February to end of March and the crop is ready for use from middle of August. Late is sown from middle of June to end of July and crop in this case provides fruit from September to middle of December. The crop can be sown on raised beds 8 feet wide with furrows for irrigation between the beds. Two seers of seed is required per acre.

TINDA GOURD

Natural Order—*Cucurbitaceæ.*
Bot. Name—*Citrullus Vulgaris Var, Fistulosus*
Vernacular Name—*Tinda.*

It is one of the most popular vegetables grown in the Punjab. Two crops are raised in the plains. One is sown from middle of February to end of April and the other from middle of June to end of July. Sandy loams or silt loams are most suited to its production. Well-rotten farmyard manure at the rate of 16 cartloads per acre may be added. Seed rate is about 2 seers per acre. It can be sown on raised beds 4 to 5 feet wide with two feet wide irrigation furrows. About 3 to 6 seeds are sown ½" deep in each hole. Irrigation is given immediately after sowing, and is followed by another irrigation 8 to 10 days later. Seed germinates within 5 to 14 days. In some areas, seed is sown broadcast in a well-prepared moist soil. The field is ridged into beds to facilitate irrigation. Early crop requires frequent irrigations. Late crop is often grown in rain-fed regions where monsoon breaks out early and rainfall is fairly certain. In dry regions, it should be watered at least once every two weeks. *Tinda* is extensively grown in certain localities such as Pathankot and Ambala. Two varieties are met with: green and pale green.

CUCUMBER

Natural Order—*Cucurbitaceae.*
Bot. Name—*Cucumis sativus*
Vernacular Name—*Kheera.*

It is grown for its fruit, which is taken raw with salt and pepper. Immature fruit is slightly bitter. A small portion from the stem end of the fruit is cut cross-wise and cut surfaces are rubbed together to remove the white froth that comes out. This is supposed to render the fruit more palatable, and remove its bitterness. The fruit is then peeled and sliced without removing the seed for table purposes. It is grown on all varieties of soils but loamy is the best. Land may be ploughed twice or thrice and manure worked in before making the seed bed. Ammonium sulphate may also be applied as a top dressing at the rate of 1½ to 2 *maunds* per acre when plants have started fruiting. Seed rate is 1½ to 2 *seers* per acre.

ARUM

Natural Order—*Aroideae.*
Bot. Name—*Colocasia antiquerum.*
Vernacular Name—*Arvi.*

It is a common vegetable in the Punjab and is grown extensively in the lower hills and sub-montane tracts, especially round large cities. The thickened underground portion which bears small tubers known as *arvi* is called *kachalu.* Street hawkers in large cities and towns carry boiled *kachalu* for sale and they are served after peeling, slicing and wetting with a solution prepared from chillies, salt and tamarind. *Arvi* is cooked as a vegetable. It prefers warm climate with abundance of moisture. It is sown from middle of February to end of April and does best on well manured loamy soils. Medium sized tubers are usually selected for sowing. Twelve to 15 *maunds* of seeds are required to plant an acre. The seed is sown on ridges 2½' apart.

In some localities *arvi* is grown along with bitter gourd, long melons and onions. Beds about 2 feet wide are made with furrows between the beds. Onions and bitter gourds or long melons are sown on one side of the bed and *arvi* on the other taking care to keep the same order of sowing in each bed. Onions are pulled green for market by the end of April but gourd and melons are allowed to remain as they continue bearing till about the beginning of June. First irrigation is given immediately, after sowing. Subsequent irrigation may be given after every 4 to 5 days till the crop germinates and plants are well established. Two to three hoeings are necessary to keep the field free of weeds. The crop is ready for harvest 5 to 6 months after sowing when the leaves begin to turn yellowish. The tubers are dug out with a spade and *kachalu* and *arvi* are sorted out for disposal in the market. Average yield is 150 to 200 *maunds* per acre.

GINGER

Natural Order—*Scitamineae*
Bot. Name—*Zingiber officinale.*
Vernacular Name—*Adrak.*

It does best in humid climate. In the Punjab, it can be grown more successfully in lower hills and sub-montane districts. It is planted in the months of March and April in plains and during May in hills. It prefers light type of soil rich in organic matter. Ten to twelve *maunds* of sets are required to plant an acre. The sets used for seed are kept from previous year's crop in a cool place, covered with moist sand. Sprouted sets with 2 to 3 buds on each should be planted, since they give better germination than unsprouted ones. The seed pieces are cut about 2 oz. each in weight and covered with fresh dung for about 24 hours previous to planting. The application of dung in this manner is said to protect the seeds from rotting and stimulate germination. The sets are planted about 2" to 3" deep in rows about 1 foot apart. After planting the surface of the seed bed is mulched with a thick layer of tree leaves to prevent the seed-bed from being washed away and drying hard when there are heavy showers of rain. It also prevents excessive loss of moisture through evaporation. In about a month's time, when leaves begin to decay and the germination of the crop has been completed the mulch is hoed in. In August fresh dung is applied as a top dressing. In the sub-montane tract it can be sown on ridges about 1½′ apart with a distance of about 10 to 12″, between sets. Irrigation should be applied soon after sowing. Inter-culture should be done to eradicate weeds whenever necessary. The crop is ready for harvest in November-December, and average yield is 100 to 150 *maunds* per acre according to locality.

SWEET POTATOES

Natural Order—*Convolvulaceae.*
Bot. Name—*Ipomaea batatas.*
Vernacular Name –*Shakar Qandi.*

This is grown more or less in all parts of the Punjab plains, where it is planted from the middle of March to the end of April. In the hills planting may be done from the beginning of April to the end of May. It can be grown on a wide variety of soil but a well-drained sandy loam is considered to be the best. The land should not be cultivated deeper than six to eight inches, because the roots in that case tend to be long and slender and are also diffcult to dig. No manure is usually applied to this crop, though it has a beneficial effect on the yield. The farmyard manure may, therefore, be applied at the rate of eight cartloads per acre, special · on light sandy soils. The crop 's usually propagated by means of cuttings of the vines. It can also be grown from plants or slips produced from roots, but vine cuttings are cheaper and produce roots more uniform in size and shape. Where the growing season is short, the vines cannot be over wintered as in higher hills, plants may be grown from roots for transplanting. Cuttings about 1 to 1½ feet long are taken and transplanted in the field on ridges 1½ to 2 feet apart and 1 to 1½ toot from plant to plant. The sweet potato is said to be drought-resistant and suffers little permanent injury when exposed to prolonged period of water deficiency. The irrigation should, therefore, be given from transplanting till the vines cover the ground. After that only occasional watering is needed. The crop is ready for harvesting in the beginning of December and should be harvested about the time the frost occurs and before the vines are killed by frost. There are two types of sweet potatoes commonly grown—one is red skinned and the other white skinned. The latter is sweeter than the former, and is, therefore, generally preferred. The yield per acre is about 175 *maunds*.

INDIAN SPINACH

Natural Order—*Chenopodiaceae*
Bot. Name— *Beta Bengalensis.*
Vernacular Name—*Palak.*

It is grown for green leaves to be used as pot herb. It can be sown early in the season to furnish "green" in September-October. It can be sown from middle of June to middle of November on the plains and from middle of March to end of May in the hills. The usual seed rate is about 16 *seers* per acre. It yields best on heavy loams. Three to four ploughings are necessary to prepare the land. The seed after broadcasting is lightly covered by raking the surface of the seed bed cross-wise. Water is applied immediately after. Spinach does not grow well unless it has abundance of moisture. The crop should be irrigated after every 8 to 10 days in summer and after about every fortnight in winter. About 3 to 4 cuttings can be obtained in a season.

Spinach or *Kandairi palak* and Newzealand spinach are also grown like Indian *palak.*

CORIANDER

Natural Order—*Umbelliferae.*
Botanical Name—*Coriandrum sativum.*
Vernacular Name—*Dhanya.*

Coriander is grown on a very small scale almost all over the province, though in some parts, especially in south-western, such as Multan, it is grown on a commercial scale as well. Coriander requires a good loamy soil. The land should be thoroughly prepared before seeding. It can be sown from September to November and harvested in April and May for seed. The vegetative part is, however, used as a condiment even 1½ to 2 months after planting. The seed rate is about 8 to 12 *seers* per acre. It can be sown broadcast. The seed should, however, be thoroughly rubbed so as to open the fruit walls before sowing. Unrubbed seed either does not germinate at all or gives very poor germination. Two to three hoeings are considered to be sufficient to keep the crop free from weeds, and 5 to 6 irrigations are necessary. The yield is about 8 to 12 *maunds* per acre. The price during 1944-45 varied from Rs. 20 to Rs. 35 per *maund*.

MINT

Natural Order—*Labiateae*.
Bot. Name—*Mentha Sp.*
Vernacular Name—*Podina*.

Mint or spear mint is grown in the gardens for its green leaves, especially for *chutney* preparation. It has abundant mineral elements and vitamins. Of all the leafy vegetables mint leaves are the richest in iron. It thrives best on loamy soils. Its propagation is usually carried on by planting divisions of old plants in rows 1 foot apart and 6 inches from plant to plant during the months of October, November, January and February. Once plantation has started it will continue to produce leaves for a number of years if the ground is liberally manured. It requires frequent irrigation, once or twice a week when the weather is dry.

LETTUCE

Natural Order—*Compositae*.
Bot. Name—*Lactuca Sativa*.
Vernacular Name—*Salad*.

Lettuce is generally eaten raw and is very much appreciated by Westerners on account of its dietetic value. In the plains it is grown in winter, and does not grow in hot weather. Lettuce seed should be sown in the fields, on both sides of the raised beds about 2 feet apart. The lettuce seed is very small and should be sown as shallow as possible, covering over with not more than $\frac{1}{8}''$ of soil. Irrigation should be given immediately after sowing. $2\frac{1}{2}$ lbs. of seed is sufficient to plant an acre. Lettuce seedlings can be raised in a nursery bed and planted in the field when about 6 weeks old. The planting distance is 15" between rows and 12" from plant to plant. In hot weather lettuce requires waterings every 4 to 5 days but in winter season it need not be watered so often. The heads when they attain full size and feel hard when pressed should be cut for use. Outer leaves of the heads should be trimmed.

CELERY

Bot. Name—*Apium greveolens.*
Vernacular Name—*Salahri.*

It is an unimportant crop in the Punjab, but in recent years its production has been taken up round about Amritsar and Ambala for its seed which is sent to U.S.A. Celery for table use is unknown in the Punjab except among the European population. The fleshy leaves stalks of the plant after being blanched are taken raw as salad and are cooked for making soup. In the plains it is grown only in winter. In colder regions it is biennial crop, *i.e.*, it produces vegetative part in the first year of its sowing and seed in the second year. In the plains it becomes annual. In the hills, seed is sown in March-April and transplanting is done in May. The crop is ready for use in November and December. In the plains, seed is sown from middle of September to end of October. Transplanting of seedlings is done in January and the crop is ready in middle of May for harvest. It can be grown successfully on sandy loams after ploughing for 5 to 6 times. The field should be well manured. The dressing of ammonium sulphate or nitrate of soda is also useful. The seed-rate is about $\frac{1}{2}$ to $\frac{3}{4}$ pounds per acre. It may be mixed with dust or sand and then sown broadcast in a well-prepared seed bed. It should be covered with fine soil. The water should be applied soon after with a sprinkling can. As the seed takes about 10 to 14 days to germinate the bed should be covered with pieces of burlap to keep it moist. Celery plant should be about ½" in diameter at the crown when ready for transplanting. For seed production plants are set in rows 2 to 2½ feet apart. For table purposes they should be set in rows 4 feet apart and 6 to 8" between the plants. Celery requires regular irrigation. During warm season watering should be done every week and in cold weather every 10 to 14 days. For weed control inter-culture should be done throughout the growing season. The harvesting is done by reaping with a sickle. The plants when cut are left in the fields to dry for two to three days. Threshing is done by beating out the seeds which after winnowing are passed through sieves for purposes of grading. The average yield is 8 to 9 *maunds* of seed per acre.

To secure early crop in the plains it is customary to bring plants ready for transplanting from the hills. They thus mature in December and January. The plants are covered with earthen pots to secure bleaching. Frost is necessary to produce a tender stem for table purposes.

Dehydration of fruits and vegetables.

During the main fruiting season there is glut in the market and prices are consequently low, whereas in the off-season, the prices are very high. The inferior quality produce, such as under-sized or injured fruits, which are more or less unsalable in the market go to waste or are sold at a very low price. In some parts of the province where means of communication are not fully developed, surplus fruit cannot be taken to the market and is liable to rot. In order to improve the conditions, the fruit and vegetable preservation and dehydration industry requires considerable attention. Although preservation of fruits and vegetables has been known all over the world for a long time, yet it has been taken up on a commercial scale in this country only recently as a result of war. The question of economy of shipping space and difficulty in transporting the bulky but protective food articles to the front lines gave impetus to the drying industry, particularly the vegetable dehydration industry. In warm climate, the fruit juices have a definite place in cold drinks. In the Punjab these juices can be consumed in major portion of the year but this industry did not make much progress in this country on account of competition from the imported stuff. Moreover, some of the manufacturers in this country resorted to using artificial flavours and colours and saccharine in place of sugar. The curtailment of imports from overseas as a result of war stimulated this industry to a considerable extent. The Agricultural Marketing Department also undertook the standardisation of these products, and now a days the Punjab Province is leading in the whole of India in the manufacture of citrus fruit products. The total quantity of fruit juices prepared annually in the Punjab and put in the Indian market is in the neighbourhood of 15 *lakh* bottles. The juices now available are of much higher quality than we used to have some years back and in the coming years, *i.e.*, after the war, it is hoped that this industry will maintain its position in this country. If need arises it should be afforded adequate protection.

The dehydration or drying industry has received impetus from the Supply Department, Government of India, which selected dehydrating contractors and contracted with them for the manufacture of definite quantities of dehydrated potatoes and vegetables for the armed forces. These contractors were required to purchase these vegetables from the open market subject to the ceiling prices fixed by the Provincial Ceiling Price Fixation Committees and dehydrated the vegetables according to the specifications and conditions laid down by the Food Department. The drying, over-all ratios, and costs of manufacture for various vegetables were fixed.

In order to study the problem of dehydration of fruits and vegetables in this country a special scheme financed by the Imperial Council of Agricultural Research was started in Lyallpur in June 1941 to meet the army requirements. The work was mainly carried on in vegetables, and consisted of (*a*) standardisation of a tunnel dehydrator (airblast type) and (*b*) working out the methods and costs of dehydration of all kinds of vegetables. As a result of investigations a standardised dehydrator consisting of a drying chamber (13'x5'x6') and a multiblade blower type fan (20" diameter with 12 blades) in the fan chamber (2½'x5'x7') for blowing the air over the heating coils, was evolved. The hot air after passing through the tunnel in which trays containing the vegetables were placed is sucked by the fan at the other end and re-circulated. During the process of drying, the temperature and humidity are controlled. The methods of dehydration of various vegetables were also standardised. The important information with regard to various vegetables is given in the table attached herewith (Page 386).

Although the dehydration of vegetables made much progress during the war, it is yet to be seen if this industry will stay in this province. At present, the civil population is more or less unacquainted with the factory-dehydrated fruits and vegetables. Of course in their own homes a part of the population have been sun-drying some of the vegetables. In order to keep this industry alive it will be essential to stimulate the demand of these products in this country.

TABLE

Methods of dehydration of vegetables as standardized in an Experimental Tunnel Dehydrator at Lyallpur.*

No.	Name of vegetable.	Preparation.	Treatments before drying.	lbs. of prepared vegetables per sq. ft. of tray surface.	DRYING TEMPERATURE AT 'cold end.'	DRYING TEMPERATURE AT 'hot end.'	Drying *time* (hours).	DRYING RATIOS. Unprepared.	DRYING RATIOS. Prepared
1	**Bitter Gourd (Karelas)**	Peel by scraping thoroughly and cut into ¼″ thick slices.	Blanch for 7-8 mts. in boiling water.	1.0—1.25	150° - 160°F.		7—9	26 : 1	15 : 1
2	**Brinjals** ..	Peel thinly with sharp knives and cut into ¼″ thick slices longitudinally.	Immerse the slices for 1½ hrs. in 0.5 per cent. SO_2 solution and then blanch in *boiling water for 4-5 mts.*	1.0—1.5	120°—130°F.		9—11	33 : 1	20 : 1
				NOTE:—The prepared slices should not at any stage be allowed to come in contact with iron, especially during blanching and drying.					
3	Cabbage ..	Remove outer leaves and cores. Shred into 3/16″ thick shreds *longitudinally.*	(*a*) Steam for 5—10 mts. (*b*) Blanch for 2-3 mts. in boiling 1.0 per cent. *sodabicarb solution.*	1.5—2.0	140°—150°F.		12—14	18 : 1	15 : 1
4	Carrots ..	Peel by scraping, cut stalks and tips and slice into 3/16″ thick slices.	Blanch for 2-4 mts. in boiling 2 per cent. common-salt solution.	1.0—1.5	155°—165°F.		14—10	18 : 1	10 : 1
5	*Cauliflower*	Remove *stalks, covering* leaves and stems, break apart the flowers and cut them to suitable size.	Blanch in water for 4-5 mts. steep in 0.5 per cent. SO_2 solution for ¾-1 hr. Wash gently.	1.0—1.5	140°—150°F.		10—12	35 : 1	18 : 1
6	Knol Khol	Remove stems, peel thoroughly and cut into 3/16″ thick slices.	(*a*) Dry as such or (*b*) Immerse for 30—45 mts. in 0.25 per cent. SO_2 solution and wash.	1.0—1.5	130°—140°F.		11—13	19 : 1	11 : 1

7	*Methi* ..	Remove foreign leaves by sorting and rotten portions by trimming.	(a) Steam for 6—10 mts. or (b) Blanch in 2 per cent. common salt solution for 15 seconds.	¾—1.0	140°—150°F.	10—12	17 : 1	9 : 1
8	*Okra* ..	Remove stalks and tips and cut crosswise into pieces ½" thick.	Blanch in boiling water for 4—8 mts.	1.0—1.5	145°—155°F.	6—8	12 : 1	9 : 1
9	Onions ..	Trim and peel to remove outer dry leave. Slice into 1/10" thick shreds.	Treat the shreds in a 5.0 per cent. common salt solution for 10 mts. and drain.	0.75—1.5	140°—150°F.	11—13	10 : 1	8 : 1
10	Potatoes ..	Peel, slice into 3/16" to ¼" thick slices.	Blanch in boiling water for 3—5 mts. Cool immediately in running cold water.	1.0—1.5	140°—150°F.	7—8	7 : 1	5 : 1
11	Pumpkin (*Halwa kadu*)	Cut into about 2" wide longitudinal strips, peel thoroughly, remove seeds and soft portions in contact with seeds. Cut the strips into ¼" thick slices.	Keep the peeled strips as well as slices in 2 per cent. salt sol. and then (a) steam the slices for 10—20 mts. or (b) Blanch in 2 per cent. common salt solution.	1.0—1.5	150°—160°F.	9—11	19 : 1	13 : 1
12	Radish (*Muli*)	Remove stalks, peel thinly and cut into 3/16" thick slices.	(a) Immerse for 1-1½ hrs. in 0.5 per cent. SO_2 sol. (b) Blanch in water for 6-7 mts., sulphur as in (a); wash and dry.	1.0—1.5	140°—150°F.	10—12	30 : 1	24 : 1
13	Spinach	Sort, trim and wash thoroughly in running cold water.	(a) Dry the washed product as such or (b) steam for 4-5 mts.	0.75—1.0	145°—155°F.	7—8	22 : 1	6 : 11
14	Squash (*Ghia Kadu*).	Peel, cut into 4 segments which should be sliced into ½" thick slices.	Treat for about half an hour in 2 per cent. common salt sol. and then (a) steam for 10—20 mts. (b) blanch in 2 per cent. salt sol.	1.0—1.5	150°—160°F.	9—11	22 : 1	21 : 1

TABLE—concluded.

Method of dehydration of vegetables as standardized in an Experimental Tunnel Dehydrator at Lyallpur—concld.

No.	Name of vegetable.	Preparation.	Treatment before drying.	lbs. of prepared vegetables per sq. ft. of tray surface.	DRYING TEMPERATURE AT 'cold end.' | 'hot end.'	Drying time (hours).	DRYING RATIOS. Unprepard.	DRYING RATIOS. Prepared
15	Tomato ..	(a) Peel by scalding in boiling water for 30—60 secs., cut into [illegible]—[illegible]" thick slices with sharp knives or (b) for powdering slice without peeling.	Dry the slices without any treatment.	1.0—1.5	140°—150°F.	9—10	27 : 1	25 : 1
16	Turnips ..	Peel, remove stalks and cut into 3/16" thick slices.	Immerse for 1-2 hrs. in 0.5 per cent. SO_2 scl.; wash and then. (a) blanch in water for 2—4 mts. or (b) steam for 10—12 mts.	1.0—1.5	125°—135°F.	11—13	28 : 1	19 : 1

NOTE.—1. Wash the vegetables thoroughly to remove dirt and other sticking matter before handling.
2. Maintain the humidity in the dehydrator as under:—Cold end—40-45 per cent., Hot end—20-25 per cent.
3. Under the heading "treatment before drying" in some cases alternative methods have been given. In such cases the quality of the dried vegetables obtained by these alternative methods was almost similar.
4. Dried vegetables can be made into briquettes (successfully made in these laboratories) of the desired size by means of an hydraulic press.

*"Dehydration of Vegetables" by Dr. Girdhari Lal and Nagina Lal Jain, Punjab Fruit Journal Vol. VIII, No. 29, Jan. 1944, issue.

References.

1. Agricultural Statistics of India.
2. Estimates of Area and Yield in India.
3. Reports on the Season and Crops of the Punjab.
4. Reports on the Operations of the Department of Agriculture, Punjab.
5. A Summary of more important results arrived at or indicated by Agricultural Stations and Research Officers in the Punjab"—1930-31 to 1934-35 and 1935-36 to 1937-38—Department of Agriculture, Punjab.
6. Vegetable Gardening in the Punjab, by Dr. Sawarn Singh Purewal.
7. "Dehydration of Vegetables", by Dr. Nagina Lal Jain Punjab Fruit Journal, Vol. VIII, No. 29, January, 1944.
8. Punjab Fruit Journals.
9. Fruit Number of the Punjab Agricultural College Magazine.
10. Reports on the Marketing of various fruits in the Punjab (unpublished).
11. Report on the Marketing of Citrus Fruits in India.
12. Report on the Marketing of Grapes in India.
13. Report of the Marketing of Potatoes in India.
14. Date-Palm, by D. Milne.
15. Department of Agriculture, Punjab's leaflet Nos. 9, 20, 32, 35, 40, 42, 44, 51, 58, 64, 68, 69, 70, 73, 77, 78, 79, 81, 88, 95, 101, 102, 107, 109, 114, 115, 121, 124, 147, 152, 154, 159, 174, 177, 178, 179, 180, 181, 182, 185, 187, 189, 190, 193 and 200.

CHAPTER XV—OILSEEDS

Oilseeds are valued for oil and oil cake. The hardening of oils by hydrogenation has extended their use very considerably. Vegetable oils or fats are very vital in peace time and especially so in war time. Their chief economic importance lies in their use as a foodstuff for man and as an industrial article. For industrial purposes, vegetable oils are largely used as lubricants, and in the manufacture of soaps, varnishes, paints, etc. To some extent the vegetable oils are also used for lighting purposes especially in the rural areas. Some of the oils are also used for the manufacture of sweetmeats. The oil cakes and meals left after the expression or extraction of oils and fats from the oilseeds constitute a product of great importance for feeding cattle. It is also used as a fertilizer. Besides this, some of the oilseeds are consumed by human beings and animals as such. For instance, coconut, groundnut aud sesamum are directly used by the human beings, whereas cottonseed constitutes an important feeding stuff for cattle.

The chemical composition of various oilseeds and oilcakes are given below:—

Oilseed or Oilcake	Moisture.	Ether extract.	Album-inoid.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter	Sand & Silica.	Total. N.
Oilseed.	%	%	%	%	%	%	%	%
Toria	7.38	38.21	19.06	23.2	15.06	4.14	2.94	**3.29**
Sarson	7.15	33.87	25.89	22.04	6.4	4.30	0.35	4.14
„ (Black)								
„ (Yellow) ..	6.15	41.37	23.61	22.25	2.97	3.40	0.25	**3.76**
Taramira	6.50	33.45	24.88	24.21	4.29	4.02	2.65	**4.23**
Mustard	8.35	41.84	18.57	22.29	4.26	4.32	0.38	**3.23**
Til (Black)	5.57	52.27	17.94	13.26	3.87	6.58	0.51	**3.06**
„ (White) ..	5.53	48.53	21.37	13.96	3.56	6.56	0.49	**3.68**
Safflower	6.23	29.33	11.37	22.97	28.08	0.68	1.34	**1.87**
Groundnut ..	4.51	50.72	27.03	14.38	1.29	2.01	0.06	**4.50**
Linseed	6.62	43.16	15.00	26.01	4.94	3.67	0.60	**2.67**
Cottonseed	6.41	13.68	13.12	38.34	24.59	3.79	0.07	**2.44**
Oilcake.								
Toria	7.40	11.34	27.88	36.42	8.32	6.44	2.20	**4.75**
Taramira	9.44	8.33	36.00	28.48	6.86	5.62	4.87	**5.76**
Mustard	8.33	10.91	24.12	33.36	5.34	7.06	0.88	**5.46**
Til Punjab	6.95	8.08	37.31	29.80	3.67	11.59	2.60	**6.29**
Safflower	12.00	3.78	16.91	41.48	19.4	4.36	2.07	**4.29**
Groundnut	7.47	11.78	43.91	27.65	3.04	4.40	1.75	**7.33**
Linseed	10.45	9.42	26.69	40.26	6.32	5.47	1.39	**4.35**
Cottonseed	9.67	7.25	18.37	39.97	17.36	5.34	2.04	**3.20**

Oilseeds grown in the Punjab are *toria*, *sarson*, *taramira*, mustard, *jinjily* or *til*, safflower, groundnut, linseed and, of course, cotton as a bye-product of cotton production. The area and production of these oilseeds in the Punjab for the quinquennium ending 1943-44 are shown below:—

Name of oilseed	*Area in acres*	*Production in tons*
Toria	309,000	67,000
Sarson	240,000	
Taramira	428,000	73,000
Mustard	9,000	
Til	84,000	8,000
Groundnut	40,000	9,000
Linseed	33,000	3,000
Cottonseed	2,607,000	390,000*

It would be observed that we are mostly interested in cottonseed and rapeseeds, chiefly *toria*. The Punjab normally produces about 11 *lakh* bales of cotton or 11 million *maunds* of cottonseed, though in good years even a total of 15 *lakh* bales of cotton and 15 million *maunds* of cottonseed are obtained. Of this, only 6 or 7 per cent. has so far been crushed for the extraction of oil and even this industry is only six or seven years old. Cottonseed contains from 16 to 18 per cent. of oil but extraction by expellers without decorticating the seed takes out about 12.5 per cent. of oil or 5 *seers* per *maund* of cottonseed. Howard says, that cottonseed fed raw to cattle is often so badly digested that cotton plants can be raised from the seed recovered from the dung. There is, thus, a big scope for eliminating this economic waste and turning it into useful industries. Most of the cottonseed oil is used at present for soap making but it can be used effectively for the production of vegetable ghee.

During the five-year period ending 1943-44, the production of *toria* and rapeseeds averaged 140 thousand tons

* It has been worked out from the total production of kapas t.. ing, one-third lint and two-third cottonseed.

or 3.8 million *maunds*, whilst the production of other seeds *viz.*, *til*, groundnut and linseed aggregated to only about 20 thousand tons. In the four-year period ending 1943-44, the net exports of *toria* and rapeseeds from the Punjab Trade Block were 7½ lakh *maunds*. On the other hand a quarter of a million *maunds* of oils and 1 million *maunds* of oilcakes were imported into the Punjab. If the oil-crushing industry is developed in this province and oilseeds instead of being exported were crushed here, unnecessary transport of oilseeds to outside areas and of importing oil and about half of oilcakes could be avoided. In order to produce within the province all the cake that is required for meeting the entire demand for feeding to cattle, the production of oilseeds shall have to be increased. During the last 3 years of war, a considerable decrease in the production of oilseeds, as shown in the table below, has taken place:—

		1940-41	1941-42	1942-43	1943-44	1944-45
Rapeseed and *toria*.	Area (Acres) ..	1,334,570	1,022,996	874,027	586,332	71,566
	Production (Tons)	176,600	157,300	133,300	85,000	129,500

It would be observed that the production during 1943-44 was about half of what it was in 1940-41. With such a low production even if all this was crushed in this province, the need for oil and oilcakes could not be met. It is, therefore, necessary that this province should make every effort to stimulate the production of rapeseeds, not only to the pre-war level but even more than that, *if it desires to become* self-sufficient in respect of vegetable oils and oilcakes, especially the latter. The crushing of cottonseed should also be encouraged in every way because, besides augmenting our supplies of oil, it would provide oilcakes for feeding to cattle in place of whole cottonseed.

TORIA

Natural Order—*Cruciferae.*

Botanical Name—*Brasssica napus* Var. *dichotoma.*

English Name—*Indian rape.*

Toria is an important cash crop to the farmers in the canal colonies, because it brings them ready cash at the time when they need money for paying revenue instalments in January. It is almost invariably grown alone and with irrigation. The most important districts growing *toria* are Lyallpur, Lahore, Sheikhupura, Multan, Amritsar and Montgomery.

It can be grown on almost all common types of soils excepting those of very sandy nature. The best yields are, however, obtained on a fairly rich loam soil. A fine tilth of soil being conducive to high yields, it is necessary to prepare the land thoroughly before sowing. The desired degree of fineness of tilth can be secured by giving 3 to 4 ploughings followed by a *sohaga* to pulverise the clods. If *toria* is sown on land of average fertility, it is not necessary to add any manure to the soil, apart from what has been applied to any previous crop in the rotation. But in case it lacks in necessary plant food an application of farmyard manure at the rate of about 10 cart-loads per acre would prove advantageous.

A seed rate of about 2½ seers per acre is sufficient. The seed may be broadcast on a moist seed-bed and covered by a light tillage with a *desi* plough followed by a light *sohaga*. The seed may also be sown on a rough seed-bed after ploughing and covered by running the *sohaga* afterwards. It is very difficult to get even germination in this crop, and patches of bare soil are frequent, and consequently the yield is reduced considerably. To obtain satisfactory germination the seed-bed should be well prepared, taking care that enough moisture is available in the soil at the time of sowing. Should there be a deficiency of moisture the seed should be kept on damp earth the night before sowing. To ensure uniform distribution the seed should be mixed with an equal amount of moist earth taken from the field, and should then be broadcast going over the field at least three times. The seed should in no case be buried deep nor should the surface be heavily pressed after sowing. Bar harrow should be run over the field after sowing to prevent the formation of crust, which is likely to be formed when *sohaga* is used. As far as possible sowing should be done in early morning or in the evening. One main reason for low yield in *toria* is that ripening of the crop is not uniform as is generally noticed in the cultivator's fields. Good care should, therefore, be taken in selecting seed from a standing crop which ripens at one and the same time.

As a result of the research work done in the Oilseeds Section at Lyallpur, it has been found that *toria* Selection 'A' gives one or two *maunds* per acre more seed than the unselected local strains. The oil content of this strain is also higher.

The first irrigation should be delayed as much as possible. Ordinarily the second watering should be given when the flowering has proceeded about half way. Experience has shown that the application of water at a later period, when most of the pods have fully developed, tends to bring about lodging, which interferes with proper pod development and reduces the yield. Recently experiments on the water requirements of crops conducted at Lyallpur indicated that a good crop of *toria* can be raised without any irrigation after sowing, provided heavy *rauni* has been done.

The crop is ready for harvest in December and January, mostly during the latter month. The plants after cutting are left in the field in light sheaves for a variable period of time depending upon the individual choice of the farmer and weather. The crop is then collected in a heap on a threshing floor. Threshing is then done by trampling with bullocks. The coarse straw is separated from the grain and fine straw by *sanga* before grain is separated by winnowing. The straw is used as fuel for boiling juice, but intelligent cultivators are converting it into compost by mixing it with manure.

The crop is peculiarly liable to the attack of aphis, which in damp season attacks flowers and shoots and causes extensive damage. It is also liable to suffer from cold and frost. Consequently it is sown earlier than other *rabi* oilseeds.

The average yield is about six *maunds* as against the record yield of 17.89 *maunds* per acre obtained from a plot of $\frac{1}{27}$th acre at the Lyallpur Agricultural Farm in 1943-44. The total production in the Punjab comes to about 67,000 tons.

SARSON.

Natural Order—*Cruciferae*
Botanical Name—*Brassica campestris* Var. *Glauca.* and *Sarson.*
English Name—*Indian colza.*

This crop, when grown for seed, is sown generally mixed with other *rabi* crops, such as gram, barley or wheat. It is mostly grown on unirrigated land in October-November along with the above crops, in furrows 4 to 6 feet apart. The important districts, where it is grown are Gurgaon, Ferozepur, Karnal, Hissar and Rohtak. In some districts particularly Sialkot and Gurdaspur it is extensively sown mixed with wheat and is removed for fodder in January and February.

When sown pure a seed rate of about 2½ *seers* per acre is sufficient but when grown with other crops in furrows, as described already, half a *seer* to one *seer* of seed depending upon the distance of the furrows is required. The seed is usually sown by means of *por* when grown with other crops.

During winter season, tender shoots of *sarson* are extensively used in the rural areas as a vegetable (*sag*). It is especially relished with maize *chapatis*. The crop is ready for harvest in the month of March, and is usually harvested before harvesting of wheat starts. The threshing and winnowing operations are similar to those of *toria*. Seven to 8 *maunds* of seed per acre is a fair average yield.

Research work on *Sarson*.

Sarson like *toria* is normally a cross-pollinated plant. Evolution of improved varieties is, therefore, rather a difficult job. However, brown *sarson* Selection A and yellow *sarson* Selection A have been found to be successful in Districts of Jullundur, Hoshiarpur, Ludhiana and Ferozepur. Of these, brown *sarson* Selection A is decidedly a higher yielder, but yellow *sarson* Selection A has a special advantage of being self-fertile and also of containing higher oil contents.

Two varieties of Japan rape: one black-leaved and the other white-leaved, have also been found quite useful for providing green fodder at the time of scarcity. These have been discussed under fodders.

TARAMIRA

Natural Order—*Cruciferae*

Botanical Name—*Eruca sativa.*

English Name—*Rochet.*

Taramira is generally considered to be a crop suited to extremely dry regions, and it is almost entirely grown as a *barani* crop. In these conditions it will give some produce whereas other crops might fail. The important districts where *taramira* is grown are Hissar, Mianwali, Attock, Dera Ghazi Khan, Shahpur, Jhelum, Multan and Muzaffargarh. Its cultivation is similar to that of *sarson*. About 2 *seers* of seed is required for an acre. It may be grown either pure or with other crops in furrows. When grown in furrows ½ to ¾ *seer* of seed per acre is needed. The average yield is reckoned to be four to five *maunds* per acre. As a green fodder, it is considered a valuable fodder for camels. Its oil, when used for massage, is considered very useful against skin diseases. It is, however, slightly irritant. *Taramira* cake or oil, when fed to cattle, is considered to have a cooling effect and also keeps off the ticks. *Dhanni* cattle breeders roundabout Gujarkhan (Rawalpindi) value it much for cattle.

MUSTARD

Natural Order—*Cruciferae*

Botanical Name—*Brassica juncea.*

Vernacular Name—*Rai*

It is comparatively unimportant oilseed crop in the province with an area of about 7,000 acres, half of which is irrigated and the other half is unirrigated. Its cultivation is similar to that of *sarson* and *taramira*. A seed rate of about 2 to 2½ *seers* per acre is sufficient. It is sown in the month of October-November, and is ready for harvest in March. Yield per acre is about 4 to 5 *maunds*.

SESAMUM

Natural Order:—*Pedalineae.*

Botanical Name:—*Sesamum indicum.*

Vernacular Name:—*Til* or *gingelly*

Til grows wild in Java and Central Asia. It is supposed to have been introduced in India from Africa before the Aryan invasion. It is grown all over India, the chief provinces being Madras and C.P. In the Punjab the area under this crop is only about 84,000 acres. It is sown either as a pure crop or mixed with other crops, particuarly cotton, *juar*, *bajra*, *moth* and *mash*. The chief districts where it is grown are Gurdaspur and Kangra, though it is grown to some extent in Multan district as well, and to a limited extent all over the province. It is very little grown in canal colonies.

General characteristics.

Sesamum is an annual herbaceous plant growing about 4 feet high. The stems are generally erect, but branch freely if thinly sown. The fruit consists of a four-celled capsule of oblong shape, which opens at the top when ripe. The seed is smaller than that of linseed, and is flat in shape, and may be either white or dark.

Sesamum in the Punjab is a *kharif* crop only, and is sown in June or July, and harvested in October or November. It grows best on light soils.

Cultivation and yield.

Two to three rough ploughings are sufficient to prepare the land for sowing sesamum. When sown alone two to three *seers* of seed are enough for an acre. In Madras, even one *seer* is considered enough. It is often grown mixed with cotton in alternate rows and in parallel lines across the field. It is also, sometimes, grown with maize or *kangni* on the borders of fields. The seed is generally sown broadcast. Heavy rain after sowing is usually disastrous and cloudy weather, rain or storm at the flowering time often result in complete failure of the crop. The yield when grown alone is about 5 *maunds* per acre.

Harvesting.

Some of the earlier varieties take about three months to ripen. Late varieties may take even 5 or 6 months. The crop is generally cut when the seed in the top fruits turns brown. If not dead ripe it can be carried straight to the threshing floor and stacked upright. If some of the pods are ripe, the plants should be shaken over a cloth carried with the harvester, when seed from the capsules that are ripe will drop on the cloth. After cutting, the plants are generally tied into small bundles and stacked on the threshing floor for a few days till the capsules ripen and open and the seed will fall out if the plants are held top downwards and shaken. This may have to be repeated if all the capsules are not open. The seed is cleaned by winnowing with *chhaj*.

Uses.

The oil extracted from the seed is valuable for human consumption. Two varieties are recognized by the trade, white and black. Of these, the white variety *til* is preferred as it yields more oil than the black type. The white variety ripens earlier than the black. This province is rather deficit in *til* or gingelly, and imports about half a lakh *maunds* every year. *Til* seeds are also used for the preparation of *rewaris* etc. In the villages during the winter season *til* is pounded with *gur* and is consumed on special occasions.

Til seed generally fetches a higher price per *maund* than even linseed.

CASTOR

Natural Order—*Euphorbiaceae.*

Botanical name—*Ricinus communis.*

Vernacular name—*Arind.*

In India, the cultivation of castor as an independent crop is very limited. It is generally grown mixed with other crops like sugarcane, *juar*, cotton, *til*, chillies, etc., particularly along the borders of the fields to serve as a wind-break or as a protective green hedge. Although some castor plants may be found growing here and there all over India, the crop is of some importance only in parts of Madras and Bombay, and to a much lesser extent in C.P., U.P. and Bihar. In the Punjab, only a few hundred acres are grown mostly in Gurgaon district. In other districts, only stray plants are met with here and there. The castor plant is very hardy and can withstand drought to a remarkable degree. It is, however, liable to suffer from frost, and fails in cold countries. Very often the plant fails to ripen its seed in the Punjab.

Varieties.

Two varieties are commonly cultivated: (*a*) large seeded perennial variety and (*b*) small seeded annual variety. The oil obtained from the former is utilized for lubricating, lighting, etc., and that obtained from latter is used for medicinal purposes.

Soil.

Castor does best in free working soils. It is not likely to be a profitable crop on rich soils. Its cultivation is, therefore, recommended only on borders of fields or on such lands as cannot be profitably utilized for raising common crops.

Preparation of land and manuring.

Two to three plonghings are enough for sowing. Farm yard manure at the rate of 10 to 15 cart-loads per acre may be applied with advantage, particularly. in the case of perennial varieties.

Growing season.

The crop is sown in July-August and is ready for harvest in March-April. The perennial variety gives a fair crop for 5 to 6 years under favourable conditions, but maximum yields are usually obtained in the second or third year after sowing.

Seed.

Healthy and well-filled seed should be selected for sowing. Soaking the seed in water for about 12 hours before sowing improves germination. The usual seed rate is 5 to 6 *seers* per acre. The seed is sown in moist seed-bed either by *kera*, *i.e.*, behind the plough or by dibbling when the area to be sown is small. Later on, plants should be thinned, so that, distance between lines is 5 to 6 feet and from plant to plant 5 feet. In the case of annual varieties, the distance should be three feet and 1½ to 2 feet respectively.

Inter-culture and irrigation. Crop can be inter-cultured by running the country plough or any other suitable cultivating implement between the lines. The crop is fairly drought-resistant, but in the absence of rains two to three irrigations may be required. Irrigation during flowering and fruiting promotes development of the seed.

Harvesting and yield. The harvesting of castor is a tedious process, as all capsules on the plant do not ripen at the same time and they have to be gathered every now and then. If ripe capsules are allowed to remain on the plants for even a few days they shed their seeds. Further the quality of the seed is adversely affected, particularly, if they are wetted by rains before being gathered. It is, therefore, a decided advantage to pluck the ripe capsules before they shed their seed. The capsules, after harvesting, should be dried in the sun for a few days, and the seeds should then be lightly beaten out by the sticks.

An average crop may be expected to yield about 10 to 12 *maunds* of seed per acre.

Pests. Several insects attack the crop. Of these white fly, jassid, and hairy caterpillar are the most serious pests. Spraying with rosin soap, in the case of the former, and lead arsenate and lime, in the case of the latter, help in checking their attack.

SAFFLOWER

Natural Order—*Compositae.*

Botanical Name—*Carthamus tinctorius.*

Vernacular Name—*Kusumbha or Kusum.*

It is not an important oilseed crop in India being grown only in a few tracts here and there in the plains. In the Punjab only 187 acres are shown to have been grown on the Upper Jhelum Canal in the year 1941-42. Formerly it was grown both as a dye and an oilseed crop, but its use as dye has declined due to other synthetic dyes having supplanted it. It is now mainly grown as an oilseed or fodder crop. The varieties grown for fodder are less spiny.

Safflower is usually grown along with other *rabi* crops such as gram or wheat. It is sometimes grown mixed with cotton also. When grown on the borders of other crops it serves as a good fence against stray cattle. The crop succeeds well on light loam soils with a fair amount of moisture. It prefers low lands and does not flourish on high lands unless there are good showers of rain. If sown alone about 8 *seers* of seed is required. The flowers appear in January-February, when they should be plucked for dye. They are, generally, picked at once when in full bloom so that they may not lose the colour when exposed to the sun. A cloudy weather at the flowering season is very harmful. The petals are then dried and beaten into powder for the market. The yellow dye can also be extracted by washing the petals in water, but the red colouring matter is extracted with alkaline solution. Cheap dyes prepared from coaltar have practically killed this industry, though owing to its association with marriage ceremonies the dye is still extracted and used locally on a small scale in many parts of India. The seed ripens in April. The plants when ready are reaped and collected into heaps in the fields with clods of earth put on each heap to prevent its being blown about by wind. When plants are quite dry, the seed is beaten out with sticks and then winnowed. The outturn per acre is usually reckoned at about 1 *maund* of dry florets for dye and about 4 *maunds* of seed per acre.

GROUNDNUT

Natural Order—*Leguminosæ*.

Botanical Name—*Arachis hypogæa*.

Vernacular Name—*Mung Phali*.

The cultivation of groundnut on a field scale in the Punjab is of a recent origin. Prior to 1913 it used to be cultivated only as a garden crop on a very small scale. It was in that year that Mr. Charanjit Singh, of village Takhran, tehsil Samrala, district Ludhiana conceived the idea of growing groundnut on a field scale. From 1913 to 1930 the crop was grown intermittently. During 1930 about 12 acres were put under groundnut. This was a great success.

Since then the groundnut cultivation has been increasing rapidly from year to year as shown by the figures given below:

1932	..	274 acres.
1933	..	985 ,,
1934	..	3,300 ,,
1935	..	12,000 ,,
1938-39	..	30,000 ,,
1941-42	..	42,000 ,,
1944-45	..	61,000 ,,

Ludhiana is by far the most important groundnut growing district in the Punjab, growing about 80 per cent. of the total area under this crop. Ambala grows about 16 per cent. and Jullundur about 4 per cent. Duraha in the Patiala State and Khanna in the Ludhiana district are the important markets for groundnut. Comparatively small quantities are also available in the Ludhiana, Samrala and Machhiwara markets.

Groundnut prefers a sandy soil but it does best where there is a two to three inch layer of sand overlying a hard clay loam, as is the case in *barani* areas of Ludhiana, where this crop is mostly grown at present. The top layer of sand acts as a mulch, while the lower layers of hard soil are rich in plant food and are retentive of moisture. The top layer of sand facilitates the penetration of groundnut pegs (gynophores) and reduces the cost of digging the nuts.

There are two varieties of groundnuts: (*a*) spreading, and (*b*) erect growing. As a result of research made on a large number of varieties obtained from many places the following varieties of the crop, namely, A_2, D_3 and B_1 among the spreading varieties and A_1 and E 4_4 among the erect growing varieties have been evolved and given out to the cultivators. Erect varieties, as a rule, are earlier in maturity, give more uniformly matured produce and are easily harvested, than the spreading types, but they are more susceptible to diseases and are low yielders. They are not, therefore, likely to be very popular. The main points for the selection of varieties are high yields, high oil content and percentage of shell to kernel and uniform maturity of pods.

The monsoon breaks by the middle or third week of June in Ludhiana district. The soil is opened first by means of country plough before the rains. Deep ploughing is harmful for the crop because the pegs in that case penetrate deep into the soil, thereby making the digging out of pods difficult at the time of harvest. After the first good shower of monsoon rain the land is ploughed again and worked with *sohaga*. The groundnut is then sown by dropping the seed in the furrows made by the country plough. About 28 pounds of kernels are used for sowing an acre. The groundnuts, to be used for seed are handshelled, a day or two before sowing. All shrivelled and damaged seeds should be rejected. Sometimes the pods are wetted before shelling, with a view to facilitate shelling, which is a laborious and tedious task. Wetting the groundnut seeds and pods improves and accelerates germination. Roughly 50 pounds of groundnuts give the requisite quantity of kernels for sowing an acre. It takes about 10 persons to shell this amount in a day, which shows that handshelling of pods is quite an expensive item in the cultivation of groundnut. In 1935 a Kirlosker decorticator costing about Rs. 185 was tried for shelling groundnuts. It was seen that this machine requires only four men to work it and is capable of shelling two *maunds* of pods in an hour. In case large areas are to be grown under the crop, this machine can be profitably used. The seed germinates in three-four days' time and the plants begin to flower about three weeks later. The 'pegs' protruding from the base of the flowers start entering the soil, where the development of the pods takes place. The pegs formed after the month of August do not form pods, presumably, because, they are unable to enter the soil on account of their origin higher up on the plant. Early monsoon is welcomed by the farmers, as it makes it possible to sow the crop early and obtain higher yields. A good rainfall during July, August and first half of September—about 18 inches is very beneficial for the crop. Occasional light showers in October are also appreciated but heavy rain during this month is considered definitely harmful. Heavy rain in November is regarded as a calamity, as it (*a*) causes some seeds to germinate in *situ*, (*b*) adds to the expense of harvesting due to the soil becoming hard, and (*c*) affects quality of the produce adversely, as the pods assume a dull appearance, some of them turning black. Such discoloured pods fetch lesser price.

It is essential to keep the groundnut crop clean of weeds. Two weedings, therefore, are necessary: one in August and second in September. Ordinarily four persons are required to weed one acre.

The crop is ready for harvest in the middle of November. The leaves get somewhat crumpled and turn yellow. The harvest should, therefore, be deferred till these symptoms appear. The prices during October are usually higher than in November. The cultivator is, therefore, tempted to harvest the crop early. This is not, however, desirable, because the harvesting of the premature crop results in discolourisation and shrivelling of the pods and consequently low price. It is considered desirable that the government should legislate that no grower should harvest his crop before a certain date fixed each year by the Agricultural Department, if other means of persuasion fail. Due to the sandy nature of the soil the harvesting is quite easy. The soil is loosened by means of a *khurpa* round about the top root where most of the pods are formed. A deeper and harder dig to cut the main root is given and the plant along with the pods is pulled out. On an average soil four persons can harvest an acre in a day. After harvesting the plants are left in the field for four or five days to dry and then collected in a heap at a convenient place for threshing. The pods are taken off the plants by means of a pitch-fork into a heap, and a few pods that remain attached to the plants are later picked out by hand. The heap of pods is then winnowed to clean the produce. Two men are required for threshing and two for winnowing the produce of an acre in a day. It is, generally, believed by the farmers that groundnut kernels eaten at the time of harvesting, when they are freshly dug and are not quite dry, cause a most serious type of constipation, which may prove fatal in some cases. The *bhusa* obtained after winnowing is considered a nourishing feed for cattle, because, groundnut is a leguminous crop. It is considered to be heating, and therefore, it is not fed to milch animals. If fed to horses it is apt to cause colic. After winnowing the produce may be dried for five to six days before it is stored or marketed. The drying before storing is necessary as there is, otherwise, a risk of the produce getting mouldy soon after storing or marketing particularly if the proper drying has been ignored during the post-harvesting period.

Cost of cultivation	Rs.	a.	p.
1. Preparatory tillage	1	8	0
2. Sowing (two men and a pair of bullocks and a plough)	2	4	0
3. Seed (25 *seers* of kernels at Rs. 3-8 a *maund*)	2	3	0
4. Ten persons for handshelling, at eight *annas* a day	5	0	0
5. Weeding (8 men at eight *annas* a day)	4	0	0
6. Harvesting (4 men)	2	0	0
7. Threshing	1	0	0
8. Winnowing	1	0	0
9. Rent including revenue	7	8	0
Total ..	26	7	0

Income			
1. Thirteen *maunds* of groundnut at Rs. 3 per *maund*	39	0	0
2. Ten *maunds* of *bhusa* at 12 *annas* a *maund*	7	8	0
Gross income	46	8	0
Net income	20	1	0

It would be interesting to compare the income from groundnut with the income of those crops which it has replaced. The crop usually sown in the type of soil where groundnut is grown generally was *moth*. The cost of cultivation in this case is Rs. 15-4 per acre against an income of Rs. 16-8, leaving a net income of Rs. 1-4 against Rs. 20 from groundnut. The substantial difference in the net income obtained from the two crops is responsible for the rapid replacement of *moth* by groundnut in this part of the province. The total area under groundnut during 1943-44 being 48,600 acres the additional income that accrued to the groundnut growers in the province by growing groundnut in place of *moth,* as calculated at the pre-war rates, amounts to Rs. 9,00,000.

Uses.

Kernels are consumed either in the form of roasted nuts or they are eaten raw, but roasted nuts are preferred, though in the south-western districts raw nuts are consumed in large quantities. The varieties having large well filled kernels are preferred for eating. The demand for groundnut for eating purposes is entirely confined to the winter months, as it is considered to be heating and dry food. The kernels are also used in small quantities by confectioners, by adding the groundnut kernel as such to some sweets in place of almond or other expensive nuts. The groundnut oil is used as a cooking medium, for adulteration with ghee and for the manufacture of vegetable ghee, but the bulk of it is used for manufacturing vegetable ghee. There are two vegetable ghee factories: one at Lyallpur and the other at Begamabad in U.P. on the border of the Punjab. The groundnut cake is used for feeding of cattle, though in other provinces it is used as manure also. Wherever groundnut cannot be successfully grown there appears to be a scope for Soya Bean which is also a leguminous oilseed.

LINSEED

Natural Order—*Lineae.*

Botanical Name—*Linum usitatissimum.*

Vernacular Name—*Alsi.*

The total area under linseed is 33,000 acres. This makes about 1·9 per cent. of the total area grown under

linseed in India. It is mostly grown in C.P., Bihar, and United Provinces. In the Punjab it is chiefly grown in Kangra, Gurdaspur, Hoshiarpur and Sialkot districts. In India it is grown for seed, while in Europe and America it is mainly grown as a fibre crop. Efforts to grow linseed for fibre in India have so far resulted in failure. A persistent effort was made in this direction in Bihar from 1907 to 1910 when a Belgian expert was engaged but the results obtained were not encouraging. The experiment was tried at the Agricultural Farms, Lyallpur and Ludhiana in the Punjab also as early as 1906 by obtaining seed of Russian flax from the Director of Agriculture, Bengal. The yield of various products per acre was as follows:

Seed	205 pounds
Fibre	127 pounds
Straw	1,754 pounds

As the process of "*retting*" was far too difficult for an average cultivator, the work was stopped. The experiment was again tried in 1921 by obtaining seed from Cawnpore. Half of the crop was harvested before the seed was ripe, while the other half was delayed till the seed was mature. Results are given below:

	Harvested when seed was unripe. Lbs.	*Harvested when seed was ripe.* Lbs.
1. Seed	Nil.	555
2. Fibre	1160	860
3. Tow	830	340

It will be observed that in securing the high yield of fibre the seed has to be sacrificed. The fibre sent to Ireland for opinion was reported to be dry and harsh and was considered equivalent in quality and value to third-grade Irish flax. It appears that a flax which produces poor oilseed produces a good fibre. Attention should, therefore, be concentrated on obtaining one product only. The trials so far made suggest that much more systematic and sustained experimental work regarding acclimatisation, selection and breeding of suitable strains, methods of cultivation, retting and scutching is required, if it is expected to grow flax for fibre in the Punjab. For flax purposes the plants should not branch too freely, and the selection should, therefore, be done on that basis, though branching can be considerably decreased by thick sowing. The types grown in India, as the crop is cultivated mostly for seed purposes, branch freely. Types Nos. 5, 23 and 31 evolved at Lyallpur give higher yields than the other varieties. These types can be successfully grown in Jullundur Division. At present the entire crop of linseed grown in the Punjab is for seed production only. The seed is mostly used for feeding the cattle. It is first ground coarsely into a meal and then mixed with wheat flour in equal or double the quantity by weight. A small quantity of *gur* is added to sweeten it, before giving to the animals.

The linseed crop is grown by itself in Kangra, while in Sialkot, Gurdaspur and Hoshiarpur districts it is generally grown on the borders of the fields around the principal crop like wheat, to prevent damage to the wheat crop from the passing animals, particularly goats. The young plants of linseed before flowering have a poisonous effect when taken by goats. The poisonous effect, however, disappears after flowering.

It prefers heavy soil. The seed rate per acre is six to eight *seers*. It is sown in October and November and ripens in March and April. As shedding of seed occurs freely when the crop is ripe, the crop should be removed to the threshing floor as soon as harvested. After drying it is generally threshed by manual labour. In Kangra, however where it is grown on a field scale it is threshed by bullocks. Sometimes it is grown mixed with peas. In this case the two crops are harvested and threshed together. The winnowing is done just like wheat. The linseed *bhusa* is used as a fuel, or for making in mud plaster for increasing the binding effect. During the crushing of oilseeds the *telis* often mix it with the seed in order to secure a binding effect on the meal.

The yield per acre is about three *maunds*. rather low, and is due to the fact that most of the linseed grown in the Kangra district, where the usual practice is to sow linseed in the standing crop of rice, and the average yield there is only 1½ *maunds* per acre. This low yield of Kangra district brings the average for the Punjab down. In other districts such as Gurdaspur, Sialkot and Gujrat the yield is about 4½ *maunds* per acre. When crushed in the country *kohlu* it gives about 25 per cent. oil. The cake is highly valued as a cattle feed. The cake is obtainable from Calcutta.

There are two types of linseed : the small seeded and the bold seeded. In Punjab generally the small seed is sown as it suits the climatic conditions best. It is late in flowering and flowers more profusely than the bold seeded variety. As winter is more severe in Kangra district the small seeded variety flowers at a time when severe winter is over and consequently escapes damage from severe cold. The bold seeded variety on account of its earliness is evidently at a disadvantage. In Kangra linseed is generally sown broadcast in standing rice and no effort is made to cover the seed with soil. Under these conditions the small seeds are said to strike roots more readily and give a better germination than the bold seeds. The yield of oil per *maund* of small seeded variety is 11 *seers* and 12 *chataks* per *maund*, while that of bold seeded is 13 *seers* and 14 *chataks*, per *maund*. It will be seen that in case of bold seeded variety the percentage of oil is about 33 per cent. as against 29 per cent. in the case of small seeded.

Linseed oil is used for manufacture of soap, paints and varnish, sports goods, medicinal uses and edible purposes, but the bulk of it, *i.e.*, 90 to 95 per cent. is used for soap manufacture.

References

(1) Reports on the Season and Crops of the Punjab.

(2) Pusa Bulletin No. 61 by Howard.

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sele

he Marketing of Rapeseeds in the

ne Marketing of Groundnut in the

Marketing of Groundnut in India.

(6) Report on the Marketing of Linseed in the Punjab (unpublished).

(7) Report on the Marketing of Linseed in India.

(8) Report on he Marketing of Castor in the Punjab *(unpublished).*

(9) Dictionary of Economic Products by Watt.

(10) A summary of more important results arrived at or indicated by the Agricultural Stations and Research Officers in the Punjab—1930-31 to 1934-35 and 1935-36 to 1937-38 —Department of Agriculture, Punjab.

(11) Department of Agriculture, Punjab's Leaflets Nos. 13, 16, 54, 148, 187 and 193.

CHAPTER XVI

FIBRE CROPS

COTTON

Natural Order—*Malvaceæ.*
Botanical Name—*Gossypium herbaceum.*
Vernacular Name—*Kapas.*

Cotton is the world's most important plant fibre. It is grown over a large part of the world between latitudes 43° N and 33° S. Although the bulk of cotton area is confined to the U.S.A., India, Egypt, Russia and China, it is cultivated in a large number of other countries as well, such as Indo-China, Siam, East Indies, Southern Europe, Anglo-Egyptian Sudan, Brazil, Mexico, Peru, West Indies, etc. The total area under cotton in the world for the four-year period ending 1942, was about 73 million acres with a production of about 29 million bales of 500 pounds each (478 pounds net—American standard). The average area and production in the important cotton-growing countries are shown below:

		Area (million acres).	*Production (million bales)*	*Yield per acre (bales),*
U.S.A.	..	23·0	12·0	0·52
India	..	22·0	4·5	0·20
*China	..	5·7	2·2	0·40
*Russia	..	5·0	3·5	0·70
Egypt	..	1·4	1·6	1·20

It will be observed that the total area under cotton in India is about the same as that in U.S.A. but the production is only about one-third. In other words, the yield per acre is only one-third of that in U.S.A. Very

*The figures for China are for three years ending 1941 and those for Russia for two years ending 1940.

high yield per acre in Egypt, *i.e.*, six times the yield in India, is noteworthy.

Area.

India which enjoys the distinction of being the birth-place of cotton had about 23·5 million acres under cotton for the quinquennium ending 1941-42 with a production of 5·5 million bales of 400 pounds each (net weight 392 pounds). The area and production for the important cotton-growing Provinces and States is shown below :—

		Area (million acres).	*Production (million bales).*	*Yield per acre (bales)*
*Bombay	..	5·8	1.1	·2
C.P. & Berar	..	3·7	0·76	·2
*Punjab	..	3·6	1·5	·4
Hyderabad	..	3·4	0·5	·15
*Madras	..	2·3	0·5	·21
*Sind	..	1·0	0·4	·4
Central India	..	1·1	0·2	·2

The yield per acre in Punjab and Sind is the highest—double that of Bombay, C.P. and Berar, Madras and Central India, and about three times that of Hyderabad.

The area in the British Punjab for the quinquennium ending 1943-44 was about 2·6 million acres. This is about 8·5 per cent of the total cotton area in India, but the total production was 11 *lakh* bales, *i.e.*, 20 per cent of the total cotton outturn of India. This is due to the high yield obtained in the Punjab, as shown in the above statement. The Punjab is in most years the most important cotton-producing province in India (see statement above). In recent years due to "Grow More Food Campaign" and comparatively low price of *desi* cotton, with the outbreak of hostilities with Japan the total area under cotton has come down to 2½ million acres. The area under *desi* cotton has decreased by 0·5 million acres, while that under American

*Including Indian States.

cotton has increased by 0·3 million acres. Even under war conditions the Punjab has retained its position as the premier cotton province both as regards staple and gross production.

The Irrigated and *barani* cotton.

Excepting the montane and submontane areas cotton is grown wherever irrigation is possible and the land not excessively sandy. In the Punjab cotton is almost exclusively an irrigated crop. Nine-tenths of the crop is normally irrigated and it is only in the extreme South-East of the Province that a moderate yield is sometimes obtained without irrigation. The season in the Punjab is shorter than in other Provinces on account of cold winter temperatures, and unless the crop is sown before the monsoon and by means of irrigation, the crop cannot yield well. The best yields are obtained in the canal colonies and the South-Eastern Districts of Hissar and Rohtak, etc.

Yield.

The average for the province may be taken at 7 *maunds* of *kapas* (seed cotton) per acre which when ginned will yield about one-third of lint or fibre and two-thirds of seed. For the canal colonies the average yield is about 8 *maunds* of *kapas* (seed cotton) per acre. The average yield of American cotton is higher than that of *desi* cotton by about one *maund* per acre as it is usually sown on better type of soil under adequate water supply.

It may be noted that the maximum yields so far obtained in the Punjab are 44 *maunds* per acre for *desi* cotton "Mollisoni 39" from an experimental plot of 1/40th of an acre in 1940-41 and 37·26 *maunds* per acre for American cotton (199F) from an experimental plot 1/36th of an acre in 1942-43 at B.C.G.A. Farm, Khanewal. These yields are 6 to 7 times the average yields. This indicates the scope for improvement.

Total production.

According to official statistics, the Punjab produced about 3 *lakh* bales of cotton of 400 lbs. each in 1906-07, which gradually rose to about five *lakh* bales in 1920-21. A large bulk of cotton till then was *desi*. The production after dropping to less than 3 *lakh* bales in 1921-22 due to partial failure of Punjab American cotton rose again and fluctuated between 5 and 8 *lakh* bales till 1932-33. It rose to over 12 *lakh* bales in 1935-36 and over $12\frac{1}{2}$ *lakh* bales in 1936-37. Since then the production has been fluctuating between 10 and 12 *lakh* bales. It must be remembered that the official figures of production are somewhat under-estimated. An enquiry made by the Indian Central Cotton Committee in 1933-34 revealed that the per capita consumption of *desi* cotton lint in rural areas was 3·7 lbs. in major cotton-growing tracts, 2·98 lbs. in minor cotton-growing tracts and 2·35 lbs. in the non-cotton growing tracts. The average for the entire province worked out to about 3 lbs. lint per capita. The consumption of American cotton was only 0·27 lbs. per head per annum, because American cotton besides being more valuable, is difficult to spin on the hand-wheel (*charkha*). On the basis of 3.27 lbs. per head the consumption of cotton in the rural areas of the Punjab works out to about 2 *lakh* bales. In addition about 25 thousand bales are used in the urban areas. If these figures were added to the cotton pressed in the factories, the total yield in the Province is not less than 12 *lakh* bales. The amount withheld from the general market varies greatly from year to year according to fluctuations in the prices of cotton and also of piece-goods. Although the area of coton in the province is proportionately not great (only about 8 per cent. of the cropped area), yet economically from the point of view of income derived from it, by the growers and those connected with the handling of the produce, this crop is second in importance only to wheat crop. Taking Rs. 10 per *maund* as the average price of *kapas*, the value of cotton crop in the Punjab is not less than 18 crores of rupees as against 52 crores from wheat valued at Rs. 5 per *maund*.

Soils suitable.

Cotton does not do well on very sandy soil, but it can be grown on any class of soil, excepting only the very lightest. It is a crop which gives a good return for manuring, or rather if grown on manured land. The cotton crop is very seldom manured directly, but is often grown on land which has received a heavy dressing of farmyard manure for some previous crop. This seems to be the better method. An average crop on unmanured land may be about 5 to 6 *maunds* per acre.

Yield on good soils.

The yield from cotton on land previously manured for maize or sugarcane may be twice or more than twice the above amount, but such a heavy crop can hardly be obtained by direct manuring. The reason for this necessity for manuring the cotton indirectly is not very obvious, but the explanation probably lies in the fact that during May, June, July and in a dry year, even in August too, the soil in a cotton field is much exposed to the sun and irrigated only at long intervals, so that, in the dry hot weather which prevails during these months, the upper soil becomes extremely dry. These are the ideal conditions under which farmyard manure can be rapidly wasted or 'burnt' out of the soil (by oxidation and denitrification). Cotton is generally manured direct only when it follows the wheat crop. Such cotton is always at a disadvantage, for it is late sown, there is not much time for thorough preparation of soil, and it is on temporarily exhausted soil. The only hope of getting any good return from such cotton is to manure it, and to water it more frequently during its early growth. It must not be thought from the above that the cotton crop is always grown on rich soil. It generally is when grown on land irrigated from wells, but in the canal colonies cotton is often sown on land which has not been manured at all, or not manured for several years.

Reasons for cotton requiring land in good condition.

One of the reasons why cotton responds so well to the effect of any manurial residues in the soil is the fact that it is almost invariably sown in land which has been fallow for but a few weeks at the most. Cotton does best when it is sown after *senji* or *berseem* following maize. The *senji* is removed in the latter part of February or in March. Both on canal land and land irrigated from wells, cotton is sometimes sown after sugarcane, and wherever a relatively large area of cotton is sown, some of it will usually have to be sown after wheat.

Practice in the canal colonies.

In the canal colonies specially Lyallpur a great deal of cotton follows *toria*, in fact when *toria* is fetching a good price more than half of the cotton will follow this crop. There is, however, a general impression among practical farmers that cotton after *toria* does not yield well. Sugarcane is removed from the soil chiefly in January and February, *toria* in January and the wheat and gram harvest starts in April. Since the cotton must be sown in May or June, it is evident that none of the soil is fallow for a long time before the cotton crop is sown, and when cotton follows wheat or gram it has to be sown soon after the field has been cleared. Cotton does better after gram than after wheat, provided, of course, that the soil on which the gram was sown is suitable for cotton, which it generally is not, since on irrigated land it is only profitable to grow gram on land which is too sandy to carry wheat. *Desi* cotton can tolerate and grow well on soils which are of medium fertility but it is very essential to sow American cottons on rich and fertile lands. Fallow lands and lands, which were previously under summer or winter fodders, gram or sugarcane, should be preferred for American cotton. There is also some evidence that cotton would do well after *mash*, *moth*, *lobia* or *guara* sown as a catch crop and ploughed in May. Round about Okara it is a well-established practice to sow cotton on land green manured with *guara* in the previous summer and left fallow during winter.

Number of ploughings.

The land on which cotton is to be sown seldom receives more than four ploughings, and often only one or two. The only exception is when cotton follows sugarcane. In this case the soil has to be ploughed and broken with the harrow to disintegrate the sugarcane stumps.

Manuring.

Generally no direct manuring is given to the cotton crop as previously mentioned. In the central districts, where area under cotton is small, people sometimes apply 15 to 20 cart-loads per acre. In the sub-montane districts, where cotton is sown along with vegetables, it usually receives a heavy dose of farmyard manure. It is, however, desirable to manure the cotton crop, particularly American variety, following exhaustive crops, like wheat and *toria*, with ammonium sulphate at the rate of 2½ *maunds* per acre just before the plants start flowering.

The time of sowing.

In the South-Eastern districts sowing starts in the middle of April, depending upon the supply of water in the Western Jamuna and Sirhind Canals and continues upto the end of May. *Barani* crop in Ambala, Gurdaspur and Hoshiarpur districts is sown by the middle of June depending upon the first shower. In Ludhiana and Jullundur, where most of the crop is irrigated by means of wells, sowing is either done as early as March or as late as June. In canal colonies, sowing is usually done from the beginning of May to the middle of June. In the South-Western districts of Multan, Muzaffargarh and Dera Ghazi Khan, where cotton sowings depend upon the inundation canals, it is usually sown in the beginning of June

Experiments have revealed that optimum time of sowing cotton crop in the central canal colony districts is from 15th May to 15th June, while in dry and arid districts of South-Western Punjab, late sowing from end of May to end of June may be practised with impunity. It should be noted that in the previous edition of this book, published in 1921 we recommended sowing American Cotton in April in the canal colonies. The incidence of *tirak*, however, has tended to delay sowing dates as given above.

Preparation of seed for sowing and seed-rate.

Cottonseed has to be prepared for sowing by *leeping* it. This is done by rubbing the seed either on the wet ground or in cowdung or in moist earth. The object of this is to remove or paste down the fibres remaining on the seed, and thus allow the seed to be separated from one another at the time of sowing. Seed from the first and late picking is not used, as it is liable to be unsound and poorly developed. The best cottonseed has usually a germination capacity of only about 70 per cent. The usual seed-rate is 4 to 5 *seers*. The experience has, however, shown that 4 *seers* of seed-rate for *desi* cotton, 6 *seers* for naked or partly-naked seed of Punjab Americans such as 4F and L.S.S., and 8 to 10 *seers* for fuzzy seeded Punjab Americans such as 289F, 289F-43 and 289-K25, *gives a very good stand*, but requires thinning. In the case of large seeded thick fuzzy varieties and the late sowing higher seed rate is very essential. The seed rate should also be slightly increased if there is reason to believe that seed is inferior in germinating capacity. Soaking of seed in water overnight prior to sowing is also recommended as this practice will greatly minimise the danger of poor germination. The soaked seed should be mixed with dry soil just before sowing so that the seeds become separate and can then be sown easily. The soaked seed should be handled very gently.

Sowing.

The land is always irrigated before sowing. If the seed is to be sown broadcast (*chhatta*), the land is ploughed once with country plough, as soon as it is dry enough. The seed is broadcast after this ploughing and the land again ploughed and levelled with *sohaga*. The second ploughing may be omitted or more commonly, if time presses, the seed is first broadcast, and the land then ploughed and levelled with *sohaga*. Before sowing the soil should be allowed to dry no more than is necessary to enable the bullocks to get on to it for ploughing. The delay of even a few hours in sowing may cause less satisfactory germination.

In the Punjab, cotton is largely sown broadcast. Only a small number of farmers have taken up sowing in line at the instance of the Agricultural Department. There is probably no great objection to sowing by broadcast on well-irrigated lands. For, there the size of fields is so small and these are further sub-divided into very small compartments (*kiaris*) for irrigation, that the subsequent hoeing must be done by hand. On the well lands, the soil is, moreover, generally, maintained in very good physical condition all the time. The cultivators in the canal colonies still follow their old methods of cultivation they practised in old districts, although it is unsuited to the new conditions. The cultivator on the canal land sows larger area of cotton and he sows it as has already been seen, on the land from which previous crop has very recently been removed and which is thus often in a very poor condition. If the crop is sown broadcast it can only be effectively inter-cultured by hand which is a very expensive method. In point of fact it is never inter-cultured effectively and the yield suffers in consequence.

In the canal colonies cotton sown by broadcast is often partially inter-cultured by ploughing between plants with *desi hal* as well; as this can be done without unduly injuring the plants. This is not done until the plants are quite big, usually in July. This does not cost much and does a certain amount of good, but it cannot be done often enough or well enough to be really effective in cultivating the soil and avoiding any excessive amount of damage to the plants.

The cost of inter-culture of broadcast field.

Sometimes, in the ordinary practice, cotton fields are hand-hoed once. This is effective so far as it goes, but this operation is expensive, the average cost being upward of Rs. 3 per acre. As it takes one man upwards of five days to hand-hoe one acre with *khurpa*, very few fields are ever hoed more than once.

Line-sowing and inter-culture.

If, on the other hand, cotton is sown in lines, it can be frequently and effectively inter-cultured at a very low cost. The plots sown in lines are hoed with a bullock-drawn hoe at least once after each rain or irrigation, until the plants are too big for it to be possible. This will be until about the middle of August as a rule. The number of hoeings will be about six on an average, though sometimes it may be even more. A man and a pair of bullocks can inter-culture four acres of cotton in a day, so that, the cost of six hoeings with a bullock-drawn hoe is less than that of one hand-hoeing with *khurpa*.

Distance between lines.

Under the average conditions of soil fertility and when the crop is sown at the optimum time, the most appropriate spacing in American cotton is 3 feet between rows and 15 inches between plants, while in *desi* cotton best outturns are obtained by spacing the rows and plants at 2½ feet and 12 inches respectively. In the case of low fertility of the soil, or when sowing is late, it is important that the distances between rows and plants should be progressively decreased. On very good soils the distance can be increased even to four feet in the case of American cotton.

Method of line-sowing.

Cotton can be sown in lines either by *kera* behind the country plough, as is commonly done with wheat, or by means of *kharif*-drill, hand-drill or *por-hal*. The *kharif*-drill, the use of which has been described in a previous chapter, sows two rows at a time. Recently it has been found that single row cotton drill evolved at Lyallpur Agricultural Station has proved most efficient for line-sowing, and it is very popular with the cultivators. Sowing in lines insures much greater and more even germination than is possible with the broadcasting method. It also permits of the use of less costly bullock power in the hoeing of crop.

Harrowing after sowing very beneficial.

A frequent cause of poor germination or failure of germination in cotton is the thin crust formed as a result of the light showers of rain which often occur at this time of the year. Practically every year a certain percentage of the cotton area has to be resown on this account. This means waste of water at a time when it is badly needed, as well as, making the crop late. Very little resowing need be done by a farmer who possesses a light harrow, such as the bar harrow introduced by the Agricultural Department and uses it just after sowing. The showers which occur at the cotton-sowing period are usually quite light, and would not be sufficient to cause a troublesome crust to form, if it were not that the surface of the soil is already much compacted by *sohaga*. Experience at Lyallpur has shown that any crusting which occurs on harrowed land is generally insufficient to do any harm whilst adjoining fields left without harrowing are so badly crusted that a zamindar with only the ordinary implements would have to re-sow them. When a crust forms on the soil immediately after sowing, and if the rain is very light, so that the soil dries very quickly, *sohaga* used very lightly and tilted upwards will break the crust without doing any great damage. If, however, the plants have started to germinate, *sohaga* cannot be used and the ordinary farmer is helpless.

Uses of the bar harrow for cotton.

The harrow should be used directly after *sohaga;* it should not be used instead of *sohaga* for covering the seed, because *sohaga* fulfils an important function in levelling the soil; and also the use of the two implements leaves a much better surface. The extra cost is not much as an acre can be harrowed in a couple of hours. The harrow should also be used to break the crust if any is formed. It can be used before the seed germinates, or as soon as the plants are a couple of inches high. It is only when the majority of the plants are just appearing above ground that the harrow will do any serious damage. It can thus often be used when the *sohaga* cannot, and it always does better work. If there are any weeds appearing, or if the crop is irrigated, the field can be harrowed again until the plants are nearly six inches high without their suffering any appreciable damage.

Watering of cotton.

It is difficult to give precise and simple instructions for the watering of cotton owing to great variation in the amount of rainfall from year to year and also to the difference between the water-holding capacities of the different types of soils on which it is grown. The following account will, however, give an indication of what appears to be the best practice on average soils in the complete absence of any rain.

If the germination of the seed is very poor, it may be necessary to irrigate only a week or two after sowing, in order to allow of the gaps being resown. This should not be done if it can be avoided, as, apart from the resowing it appears to do no good. Otherwise, American cotton sown in May will need about two waterings by the end of July, *i.e.*, it needs waterings at intervals of four or five weeks. Experiments at Lyallpur tend to show that about two waterings before mid-July are ample. During the next

7 or 8 weeks, in the absence of rain, at least three waterings may be given with advantage at intervals of 14 to 18 days. This carries the crop on to about the middle of September. After about another month a last watering appears to improve the quality of the fibre of the last pickings, even if it does not greatly affect the yield. *Desi* cotton will receive just about the same irrigations, excepting that the last watering is less necessary, but in this case it is usually given for sowing of *senji*. With either kind of cotton slightly longer intervals are permissible during the early part of the season if the crop is in lines and frequently inter-cultured.

Naturally any of these irrigations may be replaced by rain; and on good soil the crop will not suffer greatly, perhaps not at all, from a further extension of the intervals between irrigations. On the other hand, if cotton is sown on light soil, it will not do well unless irrigated more often than suggested here. A crop directly manured is said to need a greater number of waterings. Irrigations after 20th October, do not materially benefit the crop, excepting in the late varieties, which may be given one watering in November. The reason that more frequent irrigation is advantageous during August, September and earlier part of October is that this is the time when flowers appear. For a large number of flowers to be formed growth must continue steadily and rather rapidly during the flowering period. Primarily the final yield depends on the number of flowers which set, so that sufficient water must be given for the steady and rapid growth necessary for the production and setting of a large number of flowers.

It will be interesting to note that cotton plant bears a very large number of flower buds, but all of them do not open into flowers, majority of them dropping before formation of flowers. It has been calculated that not more than 25—30 per cent. buds open into flowers. Again all these flowers do not produce bolls. Experiments conducted at Lyallpur show that in the case of 4-F 61 per cent. and in the case of 39 Mollisoni 65 per cent. flowers fall without making bolls. Further, all the bolls set do not open and contribute to the yield of *kapas*. Some of them may drop, while others may not open due to severe cold. Exact information on this point is not available. It has also been found out that it takes 324 bolls in the case of Mollisoni and 270 bolls in the case of 4-F to produce 1 lb. of *kapas*.

From the information given above we can work out the number of bolls required per plant to produce a certain quantity of *kapas* per acre. Taking the total number of plants to be 9,680 per acre in the case of American 4-F, and 14,000 for *desi* Mollisoni only 18 and 15 bolls per plant respectively are required to produce 8 *maunds* of *kapas* per acre. It will, thus be seen that the number of buds, flowers and even bolls borne on a plant are not necessarily an indication of the yield of *kapas*. It also indicates that there is a tremendous waste of plant energy in producing larger number of buds and flowers which never set and if set do not open to produce *kapas*. It is evident that there is a great scope for research on this important point either by way of evolving varieties or by finding out cultural, hydraulic and manuring practices, so as to reduce the shedding of buds, flowers and bolls. By increasing the number of bolls that open on the plants, surely the yield can be considerably increased. It would also be interesting and advisable to investigate the shedding percentage of buds, flowers and bolls in those places or plots where high yields of over 30 or even 40 *maunds* of *kapas* are obtained, so as to find out the factors which contribute towards the high yield. When this has been done, it should not be difficult to produce such favourable conditions in other places as well.

Picking.

Picking of cotton starts from the end of August or beginning of September in the case of *desi* and early strains of the Punjab American cotton, from middle ot October in the case of 4-F and end of October or beginning of November in the case of 289/F and L.S.S. The date of first picking may fluctuate within a fortnight, from season to season depending upon the weather conditions. In wet years there is excessive vegetative growth which makes the crop late. In years of drought the crop may be ready earlier than the normal time. In the South-Eastern tract picking starts about a fortnight earlier than in the canal colonies.

The pickings of American cotton go on until last bolls are killed by frost in January. With a heavy crop of country cotton the pickings go on almost as long; in a poor year the pickings finish in December.

In all the different tracts the first picking is small but after 15 or 20 days rush starts and the bulk of the crop is removed in 8 to 10 weeks after the first picking.

Method of picking.

The picking is done chiefly by women, children and menials, who pluck the seed cotton from open bolls. In some parts round about Khanewal, particularly in the *Jangli* villages the pickers remove complete bolls from the plant and pick out *kapas* at leisure in some corner of the field. The crop is picked at very short intervals of not more than 10 days, especially in the case of *desi* cotton and at larger intervals in case of American, when the bolls are opening in the greatest number. The total number of pickings is as large as 8 to 12 in the case of *desi* and 4 to 6 in that of American cotton. *Desi* cotton has a tendency to drop the *kapas* when picking is unduly delayed. This accounts for more frequent pickings in this case.

Cost of picking.

The pickers are paid by a share of their picking. The share given, depends on the amount of cotton on the plants ready for picking at the time. In the case of the first or the last picking when there is not much to be got off an acre, the proportion paid may be as high as a quarter or even sometimes a half. During the middle of the season the proportion is 1/12th or even 1/61th. The proportion of the whole crop given to the pickers is reckoned to be about 1/10th and is probably often as much as 1/8th. The cost of picking comes to about 2/3rds of what is paid in Texas in the United States of America. One labourer can pick about 15 *seers* of *kapas* in about 6 hours.

Leaf in picked cotton.

Owing to the dry atmosphere during the picking season and later (after November 15th) owing to night frosts the leaves become brittle. Early pickings up to the end of November are much cleaner than later ones. They contain only small parts of red leaf.

Later, after mid-November if ground frosts have been heavy the bract leaves which are black in colour are more apt to be present in the cotton. It is only in case of *Jangli* villages where the whole boll is picked that excessive amount of 'bracteoles may be present. On the whole the picking is done cleanly and carefully. In the U.S.A., picking is on the whole cleaner because the leaves are green during the picking season. The actual picking in the U.S.A. is much rougher, but American cleaning machinery in the ginneries can deal with even boll locks.

There is, however, some carelessness in the matter of mixing with the clean cotton the stained locks off the ground or off the plant, and improvement in this respect is possible.

Experiments in clean picking.

The question of clean picking has been receiving the attention of the Indian Central Cotton Committee. An experiment conducted in 1923 showed that the extra cost involved in clean picking was Rs. 1/8/- for *desi* and Rs. 1/4/- for American per 100 lbs. of cotton, besides loss in weight involved. Since the trade did not offer enough premium to cover the extra cost of picking clean cotton the farmers had no inducement to do it. These results were subsequently confirmed by experiments conducted in this province in 1934, when it was ascertained that the additional cost per *maund* of clean picked *kapas* was Re. -/3/4 in the case of 4-F and Re. -/5/2 for *desi* cotton. This comes to 13 *annas* and Rs. 1/4/- respectively per 100 pounds of cotton (lint). In addition there was a loss on the value of stained *kapas* which was removed during picking. No premium was actually obtained for the clean picked *kapas*, but buyers estimated that it was worth *annas* two to *annas* 4 per *maund* more than the *kapas* picked in the ordinary way.

Damping *kapas*.

In the later part of the season some seed cotton is brought into the markets containing more moisture than it should. It is often said that cotton in the villages is placed in watercourses or in damp rooms deliberately, so that it may absorb moisture. This, possibly does occur, but it is certainly not very common. For one thing, it is unnecessary. In the later part of the cotton picking season the dew is heavy in this Province, and the pickers generally do not start work until late in the day in order that the cotton may dry before being picked. If it is desired to have the cotton moist, it is only necessary to start picking a little earlier. There is, undoubtedly, carelessness in not drying cotton after picking, and this is the chief cause of the damp cotton, or cotton deteriorated by damp storage, which is found in some markets. In some parts of the canal colonies inhabited by *Janglis*, however, the practice of damping cotton does exist. Besides picking cotton early in the morning when the dew is still on, the *kapas* is placed in wet watercourses so as to absorb moisture, and consequent increase in weight. Those who indulge in this practice little know the harm they are doing to cotton and the trade in that particular tract. The lint is fine and silky but deteriorates on storing as it is liable to ravages of moulds, bacteria and other decomposing organisms. The cotton becomes badly stained and its strength is considerably reduced. Such cotton will give higher waste loss in the form of "fly" and the yarn spun from it will be comparatively weak and gives trouble in the dyeing and finishing process. Dampness also spoils the germinating power of the seed.

Responsibility of the buyers.

The bulk of the seed cotton coming into most of the Punjab markets is in a very fair condition, and the remedy for any carelessness lies in the hands of the buyers, as they can differentiate fairly between lots of varying cleanliness. Actually deductions from the price, on account of dirt or damp are commonly made by the ginners who buy seed cotton; but in many places these deductions are not in very strict relation to the quality of the different lots, so that they have little educative effect. If prices are falling, allowances are inclined to be substantial, whereas in a rising market the buyer takes without allowance *kapas* which is not up to standard.

Sale of *kapas* and cotton.

With the exception of a few large estates and a number of big landlords who can afford to withhold part of their surplus produce in the hope of getting better prices, later, most of the cultivators dispose of their marketable produce as soon as the bulk of it has been gathered. Nearly 60 per cent of the marketable cotton is sold during November, December and January, as the cultivators have to pay land revenue and water rates which are due in December and January. About 95 to 98 per cent of the crop is sold by the end of March.

Almost the whole of the seed cotton is bought by the owners of the local ginning factories who sell the lint after ginning, either to the local representatives of the exporting firms or mill owners or in Bombay through brokers. Factories work at full swing during November, December, January and February. Local sales of cotton are made on basis of unpressed cotton with a fixed pressing charge added. This latter is nowadays ten rupees a bale.

Malpractices.

The farmer on reaching the market hands over the *kapas* to the *arhatiya* who is responsible for the completion of the sale and protecting the interests of the seller. A number of unfair deductions are sometimes made by the buyer—especially in case of carts where the quality inside cannot be easily examined until delivery is being taken. It is then difficult for the seller to reload his goods and he is sometimes penal lised unfairly in consequence. On the other hand some small dealers deliberately put mixed or *desi* cotton in the middle of cartloads and the buyer must protect himself. Since 1941 the Agricultural Produce Marketing Act has been in operation and charges are fixed in all markets by Marketing Committees. Malpractices are gradually disappearing in consequence.

Ginning of cotton.

There are two main types of gins which are used for ginning cotton—(1) hand gins, and (2) power gins. The hand gin is the oldest type of device used for separating fibre from cotton seed. It is made of wood and has two rollers set close to each other. The upper roller is an iron bar and the lower is made of wood. In the older types both the rollers were made of wood. Hand gin is usually employed for ginning small quantities of *kapas* for domestic purposes only. Before ginning, *kapas* is dried in the sun and opened up by beating with a stick. A woman on an average can gin about 7 *seers* of *kapas* per day. The 'fly' loss in this case is small, only about 5 per cent.

The power gin machines are of two types, *viz.* single and double roller gins and saw gins. The gins most commonly used in this province are single roller gins, manufactured by Platt Brothers, Manchester. In a large factory a battery of 20 gins usually forms a set planted on two sides of the passage in the upper storey of the building. The seeds are dropped in the room below. The *kapas* to be ginned is placed on the platform and fed into the machine by the labourers (generally women). Before bringing it to the platform, *kapas* is usually passed through an opener, where a good deal of dust and dirt is removed and the *kapas* becomes fluffy. The usual capacity of the machine is 1½ *maunds* to 2½ *maunds* of *kapas* per hour depending upon the variety, and condition of the *kapas*. Larger quantity of *desi kapas* and of smooth seeded American is ginned per hour than of fuzzy seeded American, such as 289/F.

Double roller gins are found mostly in South-East Punjab. The capacity of a double roller gin is about 1½ times that of the single roller gin and not double as is sometimes considered. There is, thus, a saving of labour. The *kapas* in the double roller gin gets such a shaking during the process of ginning that dust and dirt are removed and the lint is, therefore, comparatively cleaner. A double roller gin, however, requires a better fitter to look after it than a single roller. In practice, however, very few double roller gins are now installed.

Saw ginnings.

With the growth of American cotton the use of saw gins has also increased in this province. They are used for ginning either pure Punjab American *kapas* or its various mixtures with *desi*. Pure *desi kapas* is rarely ginned on these machines. The output of a 'saw gin' with 80 saws of 12″ diameter varies from 15 to 20 *maunds* of *kapas* per hour or about ten times as much as a single roller machine would do. In other words one roller gin equals eight saws. The saw gins are becoming very popular on account of their large output and great saving of labour. Some of the machines are fitted with self-lifting and self-feeding arrangement which further reduces the cost. The 'fly' loss is , however, larger than in the case of roller gins. Some lint is left on the cotton seed. On an average a *maund* of American cotton ginned by roller gin might give 13 *seers* 4 *chhataks* of lint and by saw gin 12 *seers* 12 *chhataks* a loss of 8 *chhataks*. The premium for saw gin cotton must be enough to cover this loss.

History of introduction of saw gins.

In 1921, when the first edition of this book appeared there was only one saw gin plant in the Punjab. It had been originally bought by Sir Ganga Ram at the request of one of the authors in 1917-18 and later sold to Ralli Bros., and installed at Khanewal. One of us erected the second saw gin in Khanewal in 1924 and since then over 30 plants have been erected in the province and more than two-thirds of American Cotton is now saw-ginned. In the next 20 years saw gins will spread further in the Punjab, Bahawalpur and Sind because they clean the cotton better and actual ginning is cheaper by saw gin than by roller gins.

It is interesting to note that the only other part of India where saw gins are found is Dharwar—the original home of introduced American Cotton.

Cost of ginning and pressing cotton.

The cotton press in this province is generally worked in conjunction with the ginning factories, and most of the expenses such as those for coal, water, miscellaneous stores, engineer's services, etc., are common to both ginning and pressing. The factory owners generally allocate one-third of the total cost of ginning and pressing for pressing alone. The cost of ginning and pressing varies a good deal depending upon the number of working days in the season, capital cost of the factory, its working cost and the number of bales ginned and pressed. In the marketing surveys on cotton in 1938-39, the cost of ginning and pressing per bale for the year 1938-39 was worked out to be about Rs. 6. The details are given below :—

	Rs.	A.	P.
Steam	0	12	0
Lubricants	0	3	0
Leather belting	0	6	0
Hoop	0	10	0
Hessian	0	5	6
Misc. stores	0	6	3
Engineering	0	6	3
Labour	0	6	0
Pressing	0	2	0
Misc. charges, such as water, insurance etc. ..	0	3	0
Interest on capital ..	1	3	3
Depreciation	1	0	0
Total ..	5	15	3 or say Rs. 6

In 1939-40 when the war started, it was worked out to be Rs. 8 per bale. During 1944, it was about Rs. 20/-.

The Indian bale.

The Indian bale weighs 400 lbs. inclusive of tare (sacking and iron bands). The average dimensions are about $48'' \times 18'' \times 18''$, and has a density of 45 lbs. per cubic foot as compared to 23 lbs. for U.S.A., and 35 lbs. for Egypt. The sacking and iron straps weigh 7 or 8 lbs., and, therefore, the nett weight of the lint is on an average 392 lbs. Most of the presses are of the above standard although recently a few have been installed which turn out bales of $27'' \times 27'' \times 27''$, but weighing about 400 lbs. The press at Mela Ram Cloth Mill, Lahore prepares bales of 246 lbs. only, but these bales are not for export purposes. In case of saw-ginned cotton there is some difficulty in pressing as the lint is very fluffy. When the lint is filled in *boras* it is allowed to rest for 24 hours. It is slightly moistened also by sprinkling water on the outside hessian or in the ground before pressing. Even then it weighs only 372 lbs. as against 392 lbs. in the case of roller-ginned cotton.

The delinting machines are of recent growth in the Punjab. As mentioned earlier the cotton seed produced by saw gins carries a small amount of lint on it and sells in the market at a discount of Re. -/-/6 to -/2/- per *maund*. To remove this disability, the delinting machines were introduced in the province. The delinting machine works on the same principle as the saw gins. It consists of a series of fine circular saws set close together on a rapidly revolving shaft. At the back of these saws, very close to these runs a long cylindrical brush which catches the fibre or linters and passes them on a reel at the back. The linters are collected on the reel into a compact felt. The cost of delinting varied from Re. -/1/- to -/1/3 per *maund* before the War. Linters are used for stuffing *kullahs* and saddlery and also locally by the poorer classes of people for quality purposes. Dealers in Sukkur buy most of linter for sale in Quetta. In the United States of America and Germany linters are put to a variety of uses such as the preparation of artificial silk and yarn, paper, lining of coats, gun cotton etc. There is, thus, a scope for the use of linters in India for these purposes.

Delinting machines.

Cotton in Bombay is sold on the basis of a candy of 784 lbs. The Bombay candy is based on the Bombay *maund* of 28 lbs. and is 28 such *maunds* or two bales of 392 lbs. net. The cost incurred in ginning, pressing and sending the bales to Bombay and selling there are somewhat difficult to estimate, for some items are reckoned as a percentage on the price, and, therefore, vary with the fluctuations in price. The following will indicate approximately the scale of these charges as they were in 1944 :

Sale in Bombay.

	Rs.	As.	Ps.
(1) Freight to Bombay per candy	40	0	0
(2) Pressing charges for two bales	20	0	0
(3) Insurance, brokerage, commission, carting at rail heads, etc. ..	10	0	0
Total charges on lint per candy	70	0	0

One candy is practically 9½ *maunds* so that the local price for loose lint corresponding to the Bombay price for the pressed lint can be calculated by deducting Rs. 70 and dividing by 9½.

Thus, if lint were worth Rs. 500 per candy at Bombay, the corresponding price per *maund* of lint in a Punjab market should be $\frac{(500-70)}{9\frac{1}{2}}=\frac{430\times 2}{19}$ or about Rs. 45-4-0.

The proportion between lint and seed in the seed cotton is about 1 : 2, so by dividing the local price of lint by 3 to get the price of 'seed cotton' per *maund* we must deduct the cost of ginning 3 *maunds* of 'seed cotton' and add the value of 2 *maunds* of cotton seed. In 1944, the rate for ginning 3 *maunds* came to about Rs. 6-8-0 and the value of the cotton seed to Rs. 8-8-0 so that Rs. 2 had to be added to the local price of the lint. If the local price of lint is Rs. 45-4 per *maund*, to get the price of seed cotton corresponding to this, on the basis given above, we have to add Rs. 2 and divide by 3; this gives us the local rate of seed cotton to be $\frac{\text{Rs. } 47\text{-}4\text{-}0}{3}$=Rs. 15-12-0.

A small part of the crop is bought in the form of seed cotton by exporting firms or mill owners who hire a ginning factory for ginning. The bulk of it is purchased by the ginning factory owners who sell the lint, usually immediately, either locally or in Bombay. As the freight on loose seed cotton is high and it is a material which is liable to damage in transit by rail, the gin owners at any particular station have a decided advantage over any other buyers in the market for seed cotton in their neighbourhood. They have not really a monopoly, for, if the price in any particular station is depressed beyond a certain degree, many sellers take their cotton by road to a better market. If *kapas* prices are 4 *annas* per *maund* lower in Khanewal than in Mian Channu which is 25 miles away, buyers from the latter place can afford to buy at Khanewal and transport the *kapas* to Mian Channu. Moreover, the ginners have never been able to combine to cut prices to any great extent, though "pools" are often formed.

Mixing of American and *desi* in ginning factories.

This is one of the biggest abuses in connection with the marketing of American cotton. The relative price to-day (1945) of *desi* and American 4F is say, Rs. 10-8-0 and Rs. 18-0-0. A mixture of 5 or 10 or 15 per cent. of *desi kapas* in American *kapas*, when ginned, gives cotton, which can scarcely be detected as a mixture, and it is certainly impossible to distinguish between 5 per cent. or 10 per cent. or 15 per cent. mixtures. A 15 per cent. admixture at above prices, if it can be passed as pure, *would give the factory owner an extra profit of about* Rs. 16 a bale or Rs. 32 a candy. It is *sometimes* advocated that in order to get pure cotton the mills and exporters should have their own ginning factories. This would be uneconomic as their overhead expenses would make their purchases dear as compared to the local factory owners, whose turnover would be greater. A cotton mill of 25,000 spindles and five hundred looms will consume about 10,000 bales of cotton altogether in a year and generally its requirements of any one type such as 4F or 289F will only be two thousand bales. Also, if a mill leases a factory, it is confined to that station for its supplies, whereas often cheaper and better cotton in any particular year can be had in other stations. A *local factory owner claims* that he mixes American and *desi* because buyers *require mixtures*. A mill or an exporting firm wishing to buy 20 per cent. mixture, as the sample submitted has been approved by either the mill or the customer or the exporter, can, by buying locally, secure exactly what he wants. It is easy by 'seed analysis' to detect exact percentage of *desi*, whereas in the cotton itself the percentage is almost impossible to define or judge accurately. The only safe procedure is for any mixing to be declared illegal and for ginning and pressing factories to be licensed and compelled to gin only pure cotton. The spinning mills can then do their own mixing and know that they are dealing with pure cotton. Sometimes the quality of the last one picking, which is often termed third picking in American, is inferior and a lot of American is often *condemned as mixed*, which may be pure, but which contains third pickings. All this complicates the problem. It is, however, vital to tackle and solve it, in the interests of American cotton growers and our customers.

History of the introduction of American cotton.

The first attempt to introduce American cotton in India was made in 1840, when a dozen American planters from the U.S.A., were settled in various parts of the country. The only place where they succeeded was Dharwar in the South of Bombay. Incidentally, it was only at Dharwar that saw gins were introduced successfully up to the second decade of this century. Only half a million acres and about one *lakh* bales are grown at Dharwar. Later came Combodia cotton in Madras early in the Century. In the Punjab, Mr. Francis (a Deputy Commissioner) tried to introduce American cotton in 1880. Scattered plants of American persisted in the fields and were common when a government farm was first started at Lyallpur in 1902. The firm of Mela Ram & Sons (Hon'ble Ram Saran Dass, C.I.E.) offered rewards for the growers of *narma* (American cotton). It was only after agricultural officers were recruited in 1906, that any real progress was made. Mr. Dobbs, the first principal of the Agricultural College, Lyallpur, made many selections and these were handed over to Mr. Milne in 1908 and the work of selection from then onward was in the hands of the Economic Botanist. Large-scale tests were made by the Professor of Agriculture and 4F was put out in 1913 and 1914. The difference in price between 4F and *desi* during the last war led to rapid extension of American cotton. The basic condition for success was canal irrigation which had made great strides with the opening of the Lower Jhelum and Lower Chenab Canals in 1902 and 1891 respectively.*

Credit for introduction of American cotton.

The credit for the introduction of American cotton in the Punjab is entirely due to Government action through the Agricultural Department. The creation of the big perennial canals by the Irrigation Department made a large area of the country suitable for this crop. The Agricultural Department fostered and advocated the growth of this crop in face of considerable

*For fuller details see references below.

difficulties, until it now constitutes the bulk of the cotton crop in the western canal colonies (which afford the most favourable conditions for the growing of this cotton), and is spreading into other districts. In 1945, it constituted 70 per cent. of the total crop. The growth of American in Bahawalpur and Sindh also owes a good deal to the Punjab. Even now seed and varieties in these two tracts emanate largely from the Punjab.

Selection and distribution of imported seed.

Two definite lines of action were immediately initiated. These were the testing of the different strains found in the seed collected from the stray plants in the local crops, and at the same time the popularisation of the crop by the distribution of imported seed, and, above all, by the organization of the sale of the produce, so as to obtain for it the premium over country cotton which it deserved. At first various methods were tried without much success, though by the organized sale some premium was always obtained, whereas, none was obtainable in the open market.

Auction sales.

Finally auction sales were organzied by the Agricultural Department. Still great difficulty was experienced, for few buyers were interested, and those who were, found themselves hampered by the unsatisfactory state of affairs in regard to ginning, already described. However, the growing of this cotton gradually spread; it received a distinct impetus in one or two years, when the *desi* crop was badly attacked by bollworm or damaged by heavy rain, from which American cotton suffers less than the country variety. By 1919 the auctions had become an important factor. In 1913 the area of American cotton in the province was estimated at 30,000 acres only but by 1919 the area had reached 350,000 acres.

Importance of using local seed.

There is no doubt that early progress was greatly hindered by the practice of importing seed from Bombay (Dharwar) instead of distributing local seed; for plants from the imported seed were not hardy under Punjab conditions. Actually most of the area referred to above, was grown from seed kept by the farmers themselves from year to year; the chief reason why progress was slow, was the fact that no important premium could be obtained for the produce.

4-F American cotton.

In 1913, the seed of a selection, 4F, from the original Punjab stray plants was distributed. This, *being a pure line selection, naturally carried* more uniform fibre, and it is a hardy heavy-yielding strain. The Great War No. 1, starting just before the cotton season of 1914, removed the difficulties in commanding an important premium for this cotton. In the selling season of 1914 the price of country cotton was below Rs. 4, due largely to the fact that this cotton was then chiefly used on the Continent in Germany, Austria, Italy and Belgium, and due to War these markets were lost. There was, however, some demand for the American cotton for use in Indian mills, and thus it fetched Rs. 6 to Rs. 7, a very important relative difference. Thus, in 1915, although the area of all cottons sown was naturally at a minimum, yet the proportion of American was much higher. Since that date the very high prices commanded by the American lint, for which there is a keen demand both in India and abroad, has caused the area to increase very rapidly.

Rise in area of American cotton.

The area under American cotton was negligible in the early part of this century and it was not recorded separately in the Season and Crop reports till 1921 when it was reported to be 401,386 acres. In 1925-26 and 1926-27 it went above 1 million acres as a result of high prices, but due to partial failure its area went down again and remained between 7 and 8 *lakh* acres from 1927-28 to 1934-35. In 1935-36, it rose to 1·3 million acres, and since then it has been more or less 1½ million acres. In 1943-44, the area was 1·8 million acres.

Indian Central Cotton Committee.

With a view to bringing about improvement and development of cotton in this country, the Indian Central Cotton Committee was established in 1921. This Committee was financed by levying a cess of Re. 0-2-0 on every bale of Indian cotton exported from India or consumed in mills in this country. Its chief functions are: (1) to advise the Central and Local Governments on all questions pertaining to cotton,

(2) to finance and direct research on problems connected with the improvement of Indian cotton, (3) to finance schemes for the extension of long and medium staple cottons and of improved varieties and their marketing, and (5) by the enactment and enforcement of various legislations such as the Cotton Transport Act, and the Cotton Ginning and Pressing Factories Act, to maintain the standard of quality of cotton grown, to prevent adulteration with inferior types, and to discourage the various malpractices which occur in a certain number of ginning and pressing factories. The Committee has also directed its efforts towards the ensuring of greater accuracy in cotton statistics, but above all, the Committee has conducted various scientific enquiries and practical researches on the improvement of Indian cotton by judicious hybridisation of existing strains, the acclimatization of imported ones, the eradication of undesirable ones, the control of cotton diseases and pests, and the prevention of boll weevil by the fumigation of American cotton before entry at Bombay. Technological research essential to securing authoritative valuation of spinning qualities of cotton and to carrying out fundamental researches on the physical and chemical properties of cotton fibres is carried out at the Technological Laboratory of the Committee at Matunga. Simultaneously the Committee popularises the use of improved varieties of Indian cotton both here and abroad in co-operation with the Empire Cotton Growing Corporation, the British Cotton Industry Research Association, the Lancashire Indian Cotton Committee, the British Cotton Growing Association and similar other bodies. The Central Cotton Committee has also been examining the possibilities of diverting short staple cotton which is produced in excess of local requirements for purposes other than the production of textiles, such as making of cotton belting, artificial leather, cotton cloth for road construction, cotton cloth for use in place of hessian and cotton bags for sugar, flour and cereals.

Consumption of Indian cotton.

With the increase in the production of Indian mills and the difficulty in importing cotton these days, considerable increase in consumption of Indian cotton has taken place. The consumption of cotton in 12 months ending August 1943 was about 43 *lakh* bales against 40 *lakh* in 1941-42, 35 *lakh* in 1940-41, and about 22 *lakh* bales in early thirties. The Indian cotton consumed by mills in 1942-43 represented about 88 per cent. of the total crop in India as compared with about 44 per cent. in 1930-31.

Cotton fund.

As a result of War and "Grow More Food" efforts, the proportion of improved varieties to total cotton has changed a good deal. In this connection, the Government of India created a special fund known as Cotton Fund by the levy of an additional duty of Re. 0-1-0 per lb. with effect from April 1942 on all imported cotton, for the purpose of steadying the market. The fund was used also for purchases of raw cotton and for assisting the cultivators to change over from short staple cotton to food crops.

The Cotton Ginning and Pressing Factories Act, 1925.

This Act was enforced with a view to providing for better regulation of 'cotton ginning' and 'cotton pressing factories.' Under this legislation, the owner of every cotton ginning factory in India has to maintain a record of all cotton ginned and pressed, in a prescribed form, and submit weekly returns, showing the total number of bales of cotton pressed during the week and from the commencement of the season to end of that week to the Director of Agriculture. Special marks are allotted to each factory consisting of a letter denoting the province in which the factory is situated together with a number denoting the factory. Every bale of cotton pressed in a cotton pressing factory is marked with a special mark denoting the number of the factory and the serial number. The serial number consists of two parts; the first part of two numerals representing the two integers of the calendar year in which the cotton year has commenced and the second part the running number of bale according to press factory register. A new series of running numbers is started at the commencement of the each cotton year from 1st September. Any bale of Indian cotton can thus be traced to the factory of origin. Thus, a bale marked P125-40—5600 would be 5600th bale pressed in 1940 in B.C.G.A. Factory, Khanewal.

Under this Act, the control is also exercised on the construction and alterations in the structure of the factories in accordance with the plans and specifications approved by the Director of Agriculture. The Director of Agriculture, the Cotton Research Botanist, Deputy Directors of Agriculture, and Extra Assistant Directors of Agriculture are empowered to enter and inspect the premises, machinery and registers of the cotton ginning and pressing factories in the usual working hours.

Varieties of cotton grown.

There are two main classes of cotton grown in this province: (1) the *desi* (country cotton) which is itself a mixture of varieties, and (2) American. These varieties are very different in appearance, the American being a bushy plant, whilst Indian cotton plant is tall and slender.

Classification of country cotton.

The country cotton of the Punjab is a mixture of several varieties classified by Mr. Gammie as follows:—

Gossypium sanguineum.

The stems and the veins of leaves are deeply tinged with red colouring matter. The flowers are pink or deep reddish purple in colour. There are varieties with leaves having narrow lobes and also varieties with broad-lobed leaves. This cotton is apparently very hardy and can withstand a hot dry climate. It forms an important part of the mixtures of country cotton grown in Multan, Jhang, and the neighbouring country. The cotton from this part of the province enjoys a high reputation on account of its bright colour. Some strains at least of this red-flowered cotton have as long lint as 4F American cotton in the Punjab. The average length of the best strains is at least 0·8 inch. The fibre, however, is coarse and will not spin above 16 counts.

Gossypium indicum.

This is devoid of the red colouring matter, and has comparatively broad-lobed leaves and yellow flowers. It constitutes the chief component in the mixture in Lahore, Amritsar, and the canal colonies.

It is known to local farmers as *desi* cotton. It yields, perhaps, the longest and finest lint of any of the Punjab local varieties; but neither the colour nor the ginning *outturn* (*kan or proportion of lint in the seed cotton*) is very good. The latter is seldom much over 32 per cent. and in some years falls to 30 per cent.

Gossypium indicum; Var, Mollisoni.

The plant is similar to the last mentioned variety, but has white flowers. The lint, however, is very different, being short, hard, coarse and rough. The ginning outturn is high, frequently approaching 35 or even 40 per cent.

Gosypium Neglectum.

With narrow-lobed leaves and yellow flowers. This does not constitute any very large part of the mixture in any part of the province.

Gossypium Neglectum: Var, Roseum.

Similar to the last, but having white flowers. This is the most important constituent of the mixture grown in the South-east of the province, and is often called Hansi cotton. The lint is similar to that of the other white-flowered variety (mollisoni), and, like that variety, it yields a very high proportion of lint, *viz.*, 37 per cent. in ginning.

Varieties of cotton recommended by the Agricultural Department.

It has now been established beyond any doubt, that a single variety, whether of American or *desi* cottons, will not ordinarily give the best results underall climatic and agricultural *conditions*. The *department has, therefore*, evolved varieties best suited to different ecological regions. The following is a brief description of the varieties at present recommended:—

(*A*).—*Desi Cottons.*

(*i*) 39-*Mollisoni*. This variety is best suited for cultivation in all the canal colonies of the Punjab and there is no variety of *desi* cotton which could excell this strain in yield in these regions. It has besides a high ginning outturn (35 per cent) and on this account it is favoured by the ginners also. American cottons have largely displaced it except in the Eastern part of the canal colonies.

(*ii*) *Mollisoni*-60-*A*-2. This variety is very well adapted to whole of the South-eastern tract, constituting the districts of Hissar, Rohtak, Karnal, Ambala and Gurgaon. Its ginning outturn is very high (38-40 per cent.) and on this account its *kapas* sells at a premium over other *desi* strains. The Southeastern tract is not suitable for Americans.

(*iii*) 119-*Sanguineum*. This variety is recommended for cultivation in the districts of Multan, Muzaffargarh and Dera Ghazi Khan, where, on account of its earliness and drought-resistance, it gives a higher yield than all mixtures of Multan cottons commonly grown by the cultivators. Its ginning outturn is 35-36 per cent. The Multan District grows only 3 per cent. *desi* and 97 per cent. American.

(*iv*) 12-*Sanguineum*. This variety has been found to be best suited for the rain-fed areas of Rawalpindi and Jhelum districts. Its ginning outturn is 33 per cent., but the lint is very fine and on this score it commands a premium in the market.

(*B*).—*American Cottons.*

(*i*) 4-*F*. This variety was given out in 1914, as a general purpose cotton for all the American cotton tracts. It is capable of giving a very good yield, but its main defects are that it is only medium stapled, and is very prone to the attack of *tirak*. The cultivator would be well advised to replace this variety, as far as possible, by the under-mentioned new strains which are not only better suited to different tracts but also possess much superior fibre properties. It must, however, be added that any variety of American cotton will be liable to bad opening under the *tirak* promoting conditions.

(*ii*) *L.S.S.* This variety is specially suited for cultivation in Lyallpur, Sheikhupura and parts of Sargodha and Jhang districts. Its ginning outturn is 32 per cent. and on account of semi-naked seed and good fibre qualities, it always sells at a premium as compared to 4-F. In the tracts where it is sown, its yield is better than 4-F and it also suffers less from *tirak*. This variety was a lucky find of Sardar Sahib S. Labh Singh, Professor of Agriculture, Lyallpur.

(*iii*) 289-*F*-43. This variety is suitable for cultivation in the Lower Bari Doab Canal Colony (except Khanewal Sub-Division), Nili Bar and the inundation canal tracts of South-western Punjab. The most noteworthy features of this cotton, besides high yield, are its tolerance to shortage of water and early maturing habit on account of which it may give the first picking along with *desi* cottons. Its low ginning percentage (*kan*) 29-30 per cent. makes it very unpopular with ginners. On account of prejudice against its large and fuzzy seed for feeding, however, its price in the market is less than that of L.S.S. This variety will probably not be heard of in five years time.

(*iv*) 289-*F*-124. This variety has been very recently evolved and is considered to be the best variety for cultivation in the whole of South-western tract, including districts of Multan, Muzaffargarh and Dera Ghazi Khan and parts of Montgomery. It is somewhat susceptible to the attack of jassids in Lower Chenab Canal Colony districts and consequently it is advisable not to grow this variety in these districts. The ginning outturn of this cotton is 34-35 per cent. The quality of lint is also very good.

(*v*) 289-*F*-*K*-25. This variety suits best Khanewal Sub-Division and the adjoining parts of Lower Bari Doab Canal Colony and Multan districts. In the Central Canal Colonies, it is very prone to the attack of jassids, and should not, therefore, be grown there. Its ginning outturn is high (34-35 per cent.) and on this account it commands a premium in the market over all other American varieties. This variety was selected at Khanewal on the B.C.G.A. Estate and has been distributed since 1932. It is the main crop of 289-F in the province up to now.

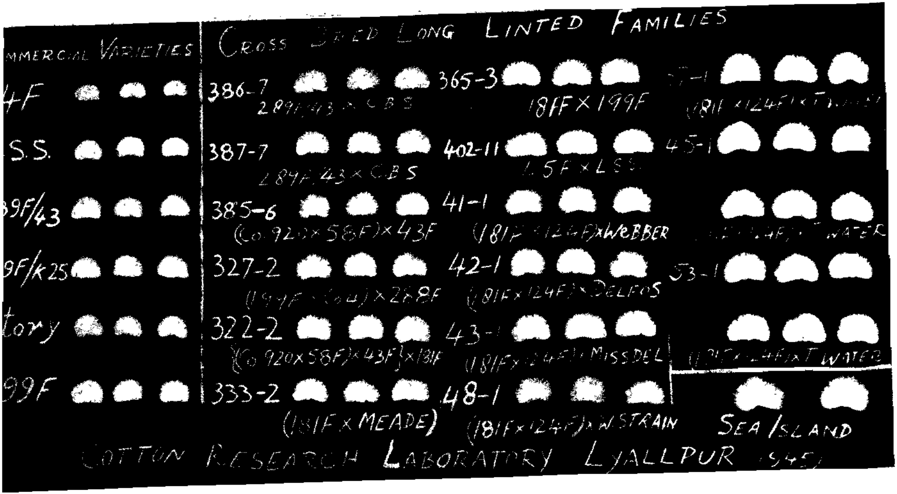

Diagram I showing how from the original 4-F we have already arrived at types like 199-F.

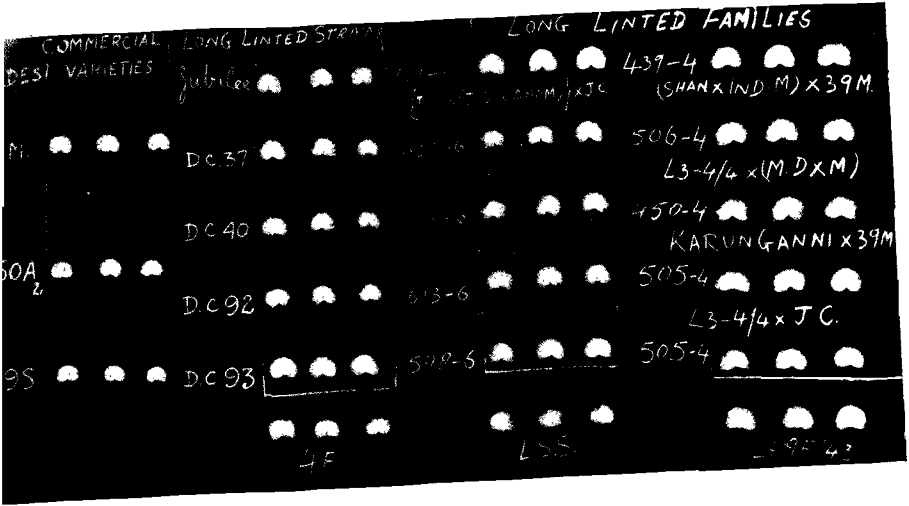

Diagram II giving an indication of work in progress on Desi cotton.

The following table shows receipt of foreign cotton (Raw) at mills in *India in Thousand of bales of 400 lbs. each.

Cotton breeding policy.

Varieties.	1938-39	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45
Americans ..	42	42	21	7	6	3	7
Egyptians ..	85	89	147	112	200	294	302
East Africans ..	246	250	242	334	118	202	181
Others: (Sudan, Burma, etc.)	72	72	165	195	102	119	120
Total ..	445	453	575	648	426	618	619

It will be seen from the above table that India has been importing about 6 *lakh* bales of foreign cotton in recent years. All this cotton is long stapled—generally $1\frac{1}{16}$ inch or better in case of East Africans and $1\frac{1}{4}$ inch or better in case of Egyptians and Sudan cottons. There is a good hope of replacing East African cottons by introducing cottons of the type of 199-F and various other crosses. The work is now in progress in Sind and the Punjab to test the possibilities of producing cottons of even Egyptian staple.

Diagram No. I shows clearly by means of "Haloes" how from the original 4-F, we have already arrived at types like 199-F, with a ginning percentage of about 34 and staple of fully 1 inch.

Diagram No. II gives an indication of the work in progress on *desi* cottons. It shows how from the original Mollisoni, and Sanguineum, new strains, which are good yielders in the field, and have a high ginning percentage and a staple which compares favourably with best 4-F American selections, have been evolved.

Fuzzy seed.

Some of the American cotton varieties such as 289-F-43 and 289-F-K-25 have got fuzzy seed. There is a widespread belief that such seeds when fed to cattle are harmful. It is owing to this belief that

*Indian Central Cotton Committee, Statistical Leaflet No. 3 of each year.

such seeds fetch lower price in the market. After actual feeding trials it has definitely been established that there is no foundation for this prejudice against such seeds. In spite of this, fuzzy seed sells at present at Rs. 5, whereas, 4-F sells at Rs. 8 per *maund*.

It is this low price of the fuzzy cottonseed that has stimulated the cottonseed-crushing industry in the Punjab round about Khanewal, where most of this sort of seed is produced. In spring 1945, about 50 oil expellers were crushing cottonseed in this tract. Most of these expellers were working independently, a few working in conjunction with cotton ginning factories. It is estimated that the total amount of cottonseed crushed in the year 1945 was about 10 *lakh maunds*. The price of fuzzy cottonseed was Rs. 5 per *maund* and that of refined cottonseed oil Rs. 39 to Rs. 39-8 per *maund*. Cottonseed cake was selling at Rs. 3-14 per *maund* at Khanewal. Due to transport difficulties large stocks of cottonseed cake had accumulated. The fuzzy cottonseed when purchased as such gives less outturn of oil because the small fibre on the seed absorbs some of the oil. It has, therefore, to be delinted. The percentage of linters removed from 289-F varies from 1 to 2½ per cent. The price of linters varies from Rs. 10-8 a *maund* to Rs. 11-8 a *maund* according to the percentage of linters removed from the seed—the higher the percentage removed the less is the price and *vice versa*. The percentage of linters removed in America was reported to be 5 per cent. in 1933-34, while in 1934-35 it was 6¼ per cent. The high percentage in America seems to be due to very rough ginning in small ginning factories.

Cotton seed oil.

The percentage of crude oil obtained from these expellers is about 11 per cent. The crude oil has to be refined before it is sold. During refining about 5 per cent. is lost, which is thrown away as waste. This varies with the age of the seed. In November, when the seed is fresh, waste is only 3½ per cent., while in July and August, it goes up to 5 per cent., which is said to be due to the development of acidity. If the refining is done in two stages the waste produced in the second operation is utilised for the manufacture of soap. The refined cotton seed oil is mostly used for soap making in Amritsar, and Sargodha, but can also be used for vegetable ghee by hydrogenation.

Uses of Indian cotton.

In India, *desi* cotton from the Punjab is used for spinning, though it will spin only a very coarse thread about 6 to 10 "counts". It is also used for mixing with finer cottons, which, if spun alone, make a thread too weak for weaving in this country. It is very suitable for this purpose on account of its roughness or curl. The country-cotton from the Punjab, when exported from India, used to go chiefly to the continent of Europe, United Kingdom, and Japan. In Europe, this cotton was apparently not used for spinning alone, but was mixed with wool in the manufacture of cheap cloth and blankets, or used for the manufacture of felted goods, padding, etc., and also in the making of gun-cotton. For this purpose *kapara*—a mixture of white-flowered cotton grown round about Giddarbaha (Ferozepore district)—is especially valued, as it mixes best with wool, being very rough and curly.

The long staple American cottons grown in the Punjab have fibres practically an inch in length. The fibre is fine but not very strong. This cotton is worth one penny or more over middling American in Liverpool. Very little 289-F, however, leaves India—exports of American are confined to the shorter staple 4-F.

Pests.

Of all the insect pests which attack the cotton crop, the most important are bollworm, jassid, white-fly and *toka*. A brief description of these pests together with the effective methods of their control are given below:—

(*a*) *Bollworm*.—There are two distinct types of this insect, (*i*) spotted, and (*ii*) pink. These types can be easily distinguished in the caterpillar stage, the former by the presence of dark brown spots on the upper side of the entire body and the latter by its pink colour.

The most effective control measures in the case of the spotted type is to prevent the carry-over of the pest from one cotton season to another. This can be accomplished by starving caterpillars of food during the period between two consecutive cotton seasons, by the adoption of the following measures on a co-operative basis:—

(*i*) Beheading the cotton sticks 2-3 inches below the surface of the ground during January to March with the help of an implement known as *kudali* so as to prevent stumps from sprouting, which provide food during the off cotton season. The new sprouts that may appear after this operation should be destroyed in April.

(*ii*) Eradication of the alternative host plants, which provide food during the off cotton season—January to April such as *kanghi booti*, *gulkhera*, *sankukra*, *sonchal*, *vilayati kanghi* and *kulehri*, etc.

(*iii*) Prevention of cultivation of *bhindi* and early cotton.

The simplest way to deal with pink bollwarm is also to prevent its moths from appearing year after year and this can be done by killing all hibernating larvae inside the seed by exposing the latter in thin layers to direct rays of sun during April, May and first half of June for one or two days. Further, every effort should be made to burn all cotton sticks by the middle of June, so that the larvae resting in the unpicked bolls on these sticks are also destroyed.

(*b*) *Jassids.*—This is a serious pest of American cottons only and its intensity is the highest in humid, wet years. This pest is not amenable to control by any of the known curative methods, and the only way of coping with this pest is to grow such varieties as have the capacity to withstand its attack. Usually varieties with rough leaves due to heirs on them are resistant to jassid attack. The American varieties, 4-F, L S.S., and 289-F-43, being distributed by the Department, possess in them this invaluable merit, though 289-F-43 is partly susceptible.

(e) White-fly (*tela*).—This pest attacks American and *desi* varieties alike, its attack being most severe in the drier parts of the province. The attack is severe in dry season and disappears with the rains. Most effective control measure for this pest is spraying with rosin compound during the months of July and August, when the attack of this insect is at its peak. In spraying, care should be taken to spray the underside of leaves from where the insects usually suck their food.

(d) *Toka.*—In South-Western districts and particularly in Dera Ghazi Khan, *toka* and *tidda* are very serious pests. These insects cut the seedlings and the attack is so severe in some years, that re-sowing has to be done a number of times.

The pest naturally decreases after the first week of June, sowing should, therefore, be done after that.

Bran mash with sodium fluosilicate in the following proportions has proved very effective. The cost does not exceed 2 annas per acre.

Sodium fluosilicate	..	.. 1 lb.
Wheat bran or rice husk	..	.. 20 lb.
Treacle	..	.. 2 lb.
Water	..	Sufficient to mix these properly.

This attracts the insects and poisons them.

Diseases.

Of the various fungal diseases attacking cotton plant, the one of the greatest importance to the farmer is root-rot, which lays bare large patches of crop, both of American and *desi* varieties. A concentrated study of the methods for counteracting this menace has shown that the damage resulting from root-rot can be effectively controlled by the following methods:—

(i) Sowing the crop in the end of June, by which time the aggressiveness of the causal fungus definitely declines. This practice can be adopted in the south-western Punjab, where as noted before, sowings till end of June can be practised with impunity.

(*ii*) In those places, where early sowings in May have to be practised, the mortality of the plants can be considerably reduced by intercropping cotton with *moth* and some other spreading fodder crop. *Moth* should be sown along with cotton and sufficient seed rate should be used so that *moth* completely covers the soil. By following this practice the cotton yields are not likely to be very high, but since the cultivator can expect some yield from the root-rot-affected area as compared to no yield at all, there seems every justification for its adoption. In order that the yield of the cotton crop is not too adversely affected, is it necessary that the intercrop should be removed by middle of August. Experiments have shown that any time from 1st to middle of August is the best for removal of the intercrop.

Tirak.

This is a physiological derangement of the cotton plant, causing premature opening of bolls which possess immature lint and seeds and is the outcome of either deficiency of nitrogen in the soil, or concentration of sodium salts (*kallar*) in the sub-soil, or both. Towards the fruiting stage, the plants on light sandy or nitrogen deficient soils show yellowing and reddening of leaves, while those growing on soils with saline sub-soil are characterized by withering of leaves a few days before irrigation. The remedies suggested for counteracting this trouble are as follows:—

(*i*) On light sandy soils, deficient in nitrogen, an application of sulphate of ammonia in August will remedy *tirak* to a very great extent, provided there is no *kallar* in the sub-soil.

(*ii*) On soils with *kallar* in the lower strata, the best method so far discovered to control *tirak* is late sowing of crop. Mid-June sowings have generally proved most efficacious for this and the farmer is advised to adopt this sowing time so far as his agricultural conditions permit. In late sowing, however, it is of paramount importance that the distance between rows and plants should be reduced and a higher seed rate used. The spacing will depend upon the date of sowing. For this purpose a schedule of sowing dates along with the spacing and the seed rate required, as worked out from the experiments conducted in this connection, is given below for the guidance of the cotton growers.

Date of sowing.	Seed rate per acre.	Distance between rows.	Distance between plants.
25 to 31 May	7—9 seers	2½—3 ft.	1½ ft.
1 to 7 June	8—10 seers	2½—3 ft.	1½ ft.
8 to 15 June	10—12 seers	2—3 ft.	1¼ ft.
16 to 23 June	14—14 seers	2—3 ft.	1 ft.
24 to 30 June	14—16 seers	1½—3 ft.	9 in.

The behaviour of different varieties to the different dates of sowing was another important feature of this investigation. The following schedule based on the results of experiments gives an idea of the optimum sowing periods for different varieties in different districts.

District.	Best sowing period.	Variety.
Sargodha and Sheikhupura ..	25 May to 15 June	L.S.S.
Lyallpur, Jhang and wet parts of Montgomery ..	25 May to 20 June	L.S.S and 4F.289F/43 if sown should be completed before 15 June.
Montgomery	25 May to 25 June	289F/K25 and 289 F/43, K 25 should not be sown after 15 June.
Multan	1 June to 5 July	289F/K25 and 289/F/124.

The cotton crop is also very liable to damage from rain or hail at certain stages of its growth. At the sowing time the seed may be prevented from germinating or very young plants may be killed by rain or hail, as already described. This often happens in sub-mountane districts in years of good monsoon. At the time of flowering, heavy rain always results in the shedding of a certain number of flowers every day throughout the flowering season; rain at intervals does not do such serious damage even though it may be very heavy. A long spell of rainy weather results in a considerable diminution of the yield.

Hail, etc.

It is also said that very hot dry weather during the periods of preliminary growth or during the period of flowering lessons the yield. This is certainly true of the province as a whole in practice, for in such a year, many fields cannot receive as much irrigation as they need. Whether it is actually true that some rainy or cloudy weather is necessary for a cotton field to give the maximum yield in this province, however much irrigation be given, is by no means so certain. In years like 1919 and 1920, when the rains stopped early and the proportion of cotton sown was high in irrigated tracts, a good deal of damage resulted through the bolls failing to open properly, and a large proportion of immature seed appeared in the first pickings. Where the water supply is ample, the damage is negligible, though it is undoubtedly fairly serious for the canal areas as a whole. In this respect, American cotton being later, suffers worse than *desi*. The most probable explanation of bad opening in a dry season is salt accumulation in the soil. In this connection some very useful work has been done by the Land Reclamation Department of the Irrigation Branch in different canal colonies and their method is to plough the soil during April-May and give heavy irrigation so as to leech out the salt and then sow rice crop, which is followed by berseem or gram according to the water supply available in the *rabi* season. Depending upon the concentration of salts in the soil it takes one to three years to remove the excess salts. It has been observed that after this treatment

Dry weather.

the cotton opens well. It seems that this would be a more permanent remedy against *tirak*.

Effect of late rain on germination of seed.

Rain, or worse still hail, late in the season when the bolls are opening naturally damages or destroys the ripe or nearly ripe bolls. It also seems to result in a failure, of much of the seed to mature and fill properly, so in the season following year of late rain it must always be expected that the germination of the seed will be poor. From all these calamaties due to the weather, except early cessation of rain, the American cotton enjoys some degree of immunity as compared to the country cotton. This is due to the fact, that the season during which the American cotton is producing flowers plentifully, lasts much longer than the corresponding season in the case of the country cotton.

Frost.

Frost seldom does much damage to Indian cotton, but it always results in the deterioration of the quality of the last pickings of American, and there are usually a certain number of bolls which are killed by the cold without opening at all. It makes a difference of quarter of a *maund*, perhaps even sometimes half a *maund*, in the yield of American cotton if the winter is mild and late.

Cost of cultivation and profit from an acre of cotton.

The average cost of producing cotton at Risalewala for the five year sending 1931-32 was worked out as follows:—

	Rs.	a.	p.
Manual labour (12.7 days)	3	15	8
Bullock labour (4.3 days)	7	6	4
Water rates	6	4	0
Seed	0	14	9
Manure	2	5	9
Implements	1	0	10
Kamins	0	10	11
Picking	6	8	5
Total ..	29	2	8

If land revenue at the rate of Rs. 7-0-9 were added, the total cost of growing cotton comes to Rs. 36-3-5. With an average yield of 7 *maunds* 37 *seers* and 15 *chhataks*, the cost works out to Rs. 4-8-11 per *maund*. The carting charges to the market being Re. 0-1-6 per *maund* and marketing expenses Re. 0-6-1 per *maund*, the total comes to Rs. 5-0-6 per *maund* in the market. As the average price per *maund* of cotton was Rs. 11-4-6 a net profit of Rs. 6-4 per *maund* was realized.

An enquiry into the cost of production of crops in the principal sugarcane and Cotton growing Tracts in India under the aegis of the Imperial Council of Agricultural Research from 1933 for three years gave the following figures:—

Particulars.	Lyallpur	Jullundur	Gurdaspur
	Rs.	Rs.	Rs.
Total cost per acre	38 12 0	57 1 4	31 10 3
Cost per maund	4 12 4	7 11 1	8 14 11
Price per maund	5 0 0	4 5 0	4 12 0
Output per acre	8 mds.	7.69 mds.	3.41 mds

In the Jullundur district, the cost is high on account of high irrigation cost, whereas, in Gurdaspur the cost per *maund* is high due to low yield of cotton.

SAN-HEMP

Natural Order—*Leguminosæ.*

Botanical name—*Crotalaria juncea.*

Vernacular Name—*Sann.*

This crop is grown in small patches all over the province, the total area being about 45 thousand acres. Of this about 21 thousand acres are irrigated and the rest is *barani.*

he important districts, where *sann* is grown are: Gurdas-ar, Hoshiarpur, Rohtak, Sialkot, Julhundur, Ferozepur ad Ludhiana.

Sann is mainly grown for the supply of fibre, the ropes om which are useful in many ways to the zemindars. t is also grown to some extent for use as green manure. Then grown both for fibre and for green manure it is sown hickly, the seed rate being about 25 *seers* per acre or even iore. It can grow on various types of soils but loamy oil is considered to be the best. To secure good crop, the ind should be thoroughly prepared. About three plough-ngs are considered to be quite sufficient. It is sown as a *harif* crop, usually about the commencement of rains. Jnder suitable conditions, the plant reaches the height of to 7 feet or even more. The crop is allowed to grow ill nearly ripe, *i.e.*, for about 4 months. It is then cut vith a sickle close to the ground or pulled up by the roots ind left exposed to the sun for 2 or 3 days, so as to allow he leaves to fall off naturally. The upper portions bearing he seed pods are also cut. The plants are then tied into onvenient bundles containing about 100 plants and steeped n water. The bundles are laid down length-wise in the vater and kept submerged by being weighted with stones. Sometimes, in order to give more time for the retting of thick bark at the butt end of the stalks, the lower parts of the bundles are kept in water for a number of days before steep-ing the whole plant in water. The length of period for which the plants are kept in water depends upon the season. In hot and damp weather, 3 to 4 days are sufficent but in cool and dry weather 1 to 2 weeks are required. The main object is to keep the plants in water till the bark will separate easily from the stem. In order to preserve colour and lustre of the fibre, it is important that the water of the pool or pond should be quite clear and not very muddy. It has been found that small and shallow pools well exposed to the sun seem to be best suited for steeping because heat hastens maceration, and consequently preserve the strength of the fibres. Deep water being cooler requires more time for retting. In the same way running water, although re-commended by some, would seem to be objectionable, owing to the longer time necessary for the degeneration of connecting tissues. The plants, after having been steeped to the desired degree, are taken out and dried. Fibre from each plant is extracted by hand. This is rather a very tedious process and is generally done at odd times or on rainy days in winter. A suitable machine for extracting the fibre is badly needed.

On an average the yield of fibre is about 8 *maunds* from irrigated and about 6 *maunds* from unirrigated fields. This crop drops its leaves during growth and being leguminous just like *guara* its roots add a store of nitrogen to the soil.

SANKUKRA OR PATSAN

Natural Order—*Malvaceæ.*

Botanical Name—*Hibiscus cannabinus.*

English Name—*Deccan Hemp.*

In the Punjab, this crop is grown only to a very small extent and mostly as a border crop to the fields of sugarcane and cotton. Its cultivation follows that of the major crops in which it is grown. It does well on loamy soils. If grown alone 10 to 15 *seers* of seed are sown in June or July and the plants harvested in October and November. After drying in the sun, the seed is separated by beating the plants on a piece of wood. The stalks after retting yield a useful fibre which is, however, not so strong as the *sann* fibre, hence unsuitable for use as strong ropes. The seed is sometimes used as a cattle feed or oil may be extracted from it. These have been frequently sent from India to England and yield from 15—20 per cent. oil. The oil is clear and limpid and forms a good lubricating and illuminating material. The seeds are also employed externally as a poultice for pains and bruises.

If sown alone, the total yield would be about 25—30 *maunds* of fibre and about 250—300 *maunds* of fuel. When the plants are ripe they should be cut quite close to the ground or pulled up from the roots. It is important that the lower parts of the stems should not be lost because they contain the best portion of fibre.

Reference

(1) Cotton—Encyclopædia Britannica.

(2) United States Department of Agriculture—Agricul-ral Statistics, 1943.

(3) Estimates of *Area* and *Yield* of Crops in India, 41-42.

(4) Report on the Season and Crops of the Punjab.

(5) Department of Agriculture, Punjab's Leaflets Nos. 17, 25, 26, 27, 122, 133, 136, 138, 139, 141, 147, 152, 159, 55, 166, 169, 173, 174, 176, 187 and 193.

(6) Report *on* the Marketing *of* Cotton in the Punjab npublished).

(7) Annual Reports of the Indian Central Cotton Com-nittee.

(8) Cotton Ginning and Pressing Factories Act, 1925.

(9) Studies in the Cost of Production of Crops in the 'unjab by S. B. Kartar Singh (1934) Board of Economic nquiry Publication No. 33.

(10) Report on the Cost of Production of Crops in the rincipal Sugarcane and Cotton tracts in India—Vol. I –The Punjab 1938—Imperial Council of Agricultural Research.

(11) Auction Sales by W. Roberts—Indian Agricultural Journal, (1918).

(12) Introduction of American Cotton in the Punjab (1918).

(13) Dictionary of Economic Products by Watt.

CHAPTER XVI.

FODDER CROPS.

Cultivated fodder crops are the most important source of fodder for livestock. The total area in the Punjab for the quinquennium ending 1943-44 was a little over 5 million acres. Of this about 3½ million acres were unirrigated. Further ⅔rds of the total fodder area is under *kharif* and only ⅓rd under *rabi* fodder crops.

It is interesting to note that large areas of fodder are grown in Montgomery, Multan, Lyallpur, Lahore and Shahpur districts under irrigation, while very small fodder areas are grown in Kangra, Jhelum, Rawalpindi, Attock and D. G. Khan, as shown by the figures for 1943-44 given below.

District	Area under fodder crops
	Acres.
Montgomery	449,393
Multan	381,384
Lyallpur	377,010
Lahore	338,979
Shahpur	292,528
Kangra	640
Jhelum	44,947
Rawalpindi	38,270
Attock	64,390
D. G. Khan	58,286

In South-East Punjab most of the fodder area is *barani*. Apart from grasses there are about 18 different fodder crops cultivated in the Punjab but only those which are more important are discussed below. *Swank*, maize, *moth* and *sarson* are also grown for fodder. These have been discussed earlier in this book.

JUAR OR CHARI

Natural Order—*Graminaceæ.*

Botanical Name—*Andropogon Sorghum.*

English Name—*Great Millet.*

This may be sown separately or in mixture with legumes, such as *guara, moth* or *mung.* The total area is about 1·75 million acres.

Research work so far carried out has produced two superior strains—J. S. Nos. 20 and 21.

J. S. 20. This is a tall growing non-sweet type, having a closed head with red or purple grain. It is less attacked by borer and fungus diseases. In trials it yielded as high as 503 *maunds* of green fodder. This selection stands storage well.

J. S. 21. This has a loose head with creamy white plump grain and is very sweet and juicy. This is the highest yielder and has given 10-30 per cent. higher yield than other *jowars* already in cultivation. One drawback is that being very sweet it cannot be stored for long periods.

The soil requirements and cultivation methods are the same as already given under *jowar* for grain except that for fodder purposes the common seed rate is 20-24 seers, but in case of improved strains a very good crop can be raised with about 16 *seers* per acre. For a seed crop about 8 *seers* per acre are enough and yield per acre varies from 8 to 15 *maunds* of grain. The stem borer at times is a serious pest and causes great damage to the crop. *Juar* is also subject to two fungus diseases, *viz.*, smut and red leaf spot.

GUARA

Natural Order—*Leguminosæ.*

Botanical Name—*Gyamopsis psoralioides.*

English Name—*Cluster Bean.*

This is a hardy *kharif* crop grown all over the province mainly for fodder purposes, though sometimes it is grown for seed as well, especially in the districts of Hissar and Ferozepur. It is also grown for green manuring in the canal irrigated areas. The total area under this crop is about 8 *lakh* acres.

This is a very useful and heavy yielding fodder crop. Crops 5 feet high can often be seen in the canal tracts, where it is generally grown mixed with *juar* or *chari* in various proportions. The operations performed with regard to preparatory tillage and sowing are the same as those for *juar*. Sometimes it is grown alone, mainly on light loamy soils. One to two ploughings are sufficient before sowing. Its sowing season extends from April to the month of June. The seed rate is about 8 *seers* when sown for seed, about 16 *seers* when grown for fodder and 18 *seers* when grown for green manuring. Higher seed rate is used for the last mentioned purpose, for, thick sowing does not allow the stalks to become too woody which are difficult to plough and do not rot speedily. The seed is usually broadcasted on a moist seed-bed after ploughing and covered with *sohaga*. In *barani* areas it is sown by means of *por*.

The crop is ready in about two months' time after sowing and gives a yield of about 225 *maunds* of green fodder per acre under irrigation and about 125 maunds in *barani* areas, or about 8 to 10 *maunds* of grain, if matured for seed. The green fodder has a high nutritive value and is relished by cattle. The stalks are, however, very woody when the crop is ripe, and if fed to cattle it often causes tympanitis. As the crop matures the leaves dry and drop on the ground thus adding a good deal of vegetable matter to the soil.

This is a most successful crop for green manuring being in this respect superior to *sann*-hemp. When grown for green manure it should be sown rather early and should be ploughed in the land in July and August.

The pods of *guara* when green are sometimes cooked as vegetable. The seed is highly valued in the South-Eastern Districts for the fattening of cattle. For this purpose it is first made into *dal* and boiled in a pan and then rubbed and worked about with hand till froth appears on the mass. A little mustard-seed oil is also added before feeding to the cattle.

TURNIPS

Natural Order—*Cruciferæ.*

Botanical Name—*Brassica rapa.*

Vernacular Name—*Shalgam.*

The total area is about 4 *lakh* acres. This is cultivated as fodder mostly in the Western districts of Multan, Montgomery, Jhang, Lyallpur and Shahpur. In the rest of the Punjab it is mostly grown as vegetable.

It requires a heavily manured soil to give good and economical yield. For fodder it is sown on flat by broadcasting the seed but higher yields can be obtained if crop is sown on ridges 18-24 inches apart; 2½-3 *seers* of seed are required for an acre. The crop is sown in September-October by broadcasting the seed on moist seed-bed which has been well prepared. In all 4-5 irrigations are enough. It is ready for feeding in 2½-3 months after sowing and fodder is available from December to February. A good crop yields 350-400 *maunds* per acre. The roots are fed whole or after chopping up into small pieces. It is believed to have a good effect on milk yield.

Swedes. This is a variety of *shalgam* very commonly grown in the United Kingdom and in Northern Europe. It is regarded as a better yielder than turnips in Europe. It was introduced as a vegetable at Lyallpur at the Students' Farm. It is extremely palatable and very superior to *shalgam* for human consumption. There is very considerable scope for increasing the area under this vegetable. Seed is obtainable from Suttons.

OATS

Natural Order—*Graminaceæ.*

Botanical Name—*Avena sativa and avena orientalis.*

Vernacular Name—*Javi.*

The indigenous oat plant is found growing in wheat and other *rabi* crops and is treated as a weed but it is extensively grown in temperate regions for grain and fodder. Its cultivation as a fodder crop was taken up in India by the military farms first and later spread in the country, though to a limited extent only round about cities and towns.

Soil requirements and cultivation are similar to those for wheat. The seed rate per acre varies from 24 to 32 *seers*. The local types of oats are very susceptible to smut. To protect the crop from this disease the seed should be steeped in formaline for 2-5 minutes. One *chhatak* of formaline mixed with 20 *seers* of water in a tub is sufficient to treat one *maund* of seed. The grain after treatment should be put in a heap and kept undisturbed for about 4 hours. It should then be dried and used for sowing as soon as possible.

There are several varieties of oats but they can be divided into two groups—early maturing and late maturing. The former type ripens along with wheat and the latter keeps green till the middle or even the end of May according to the season.

The early maturing type requires 2-3 irrigations while the late types require one more irrigation, if sown for grain and 2-3 more irrigations during April and May, if sown for fodder. Early type can give 2 cuttings one in January and second in March. There are 3 varieties of late oats recommended by the Agricultural Department.

French husked.—It has a thick straw and a broad and course leaf. It is the last to mature. It has given best results in Lyallpur and Gurdaspur. It gives heavier yield than the other two but only when the season remains comparatively cool in March and April and plentiful irrigation is available.

Algerian & F. O. S. 1/29.—These two are very fine in their straw and leaf, which makes them very desirable from the hay point of view as well. They have a higher tillering capacity and are more drought resistant than the French oats, and, therefore, do well even under *barani* conditions, or where moisture is restricted. The Algerian oats have given the best results at Montgomery and Jullundur, while F.O.S. 1/29 has beaten all other types at Rawalpindi. Under favourable conditions yields as high as 500 *maunds* per acre have been obtained from these varieties.

Oats can be converted into very good silage, either alone or in mixture with *berseem*. When matured for seed the local type ripens along with wheat. The late oats, when sown in the beginning of October, ripen in the end of April if no cutting is taken, when sown from the middle of November to middle of December it ripens in the end of May. The yield of grain in case of French oats is lower, as it is affected much by the hot winds. The other two varieties of late oats, namely Algerian and F.O.S. 1 are not affected much and yield about the same as wheat. If the land is rich it is possible to obtain seed after taking one cutting for green fodder in January. The maturity in this case is delayed and the yield of grain is lower than the normal crop. The grain of oats is very nutritious and can be used as a concentrate for all kinds of livestock, specially for horses, while green oats converted into hay provide richest food for cattle.

INDIAN CLOVER.

Natural Order—*Leguminosœ*.

Botanical Name—*Melilotus parviflora*.

Vernacular Name—*Senji*.

Senji is a leguminous fodder grown from ancient times in the province. Although it is being replaced by *berseem* and to some extent by *shaftal*, yet it occupies fairly large areas. Its cultivation has probably suffered less in sugarcane growing tracts. Sugarcane is commonly grown after *senji* and in this respect *shaftal* and *berseem* cannot replace it as they occupy the field for a much longer period. It is usually sown in the standing maize or cotton during the later stages of their growth. The water given to it also assists the outgoing crops which might otherwise be grudged the later watering. Like other leguminous crops it enriches the soil. The area under *senji* is estimated to be about 5 *lakh* acres.

Sowing takes place in September and October. The seed rate is from 20 to 25 *seers* per acre of husked seed. In order to help germination the seed is beaten lightly before sowing. The seed is either broadcasted in standing water or in dry soil. In the latter case it is immediately irrigated.

The first irrigation after sowing is generally given within ten days, and afterwards water is applied as requried, generally every 15 or 20 days.

The following are the common rotations in which it enters:—

Maize—*Senji*—Sugarcane—wheat or cotton.

Maize—*Senji*—Cotton—Wheat.

Cotton—*Senji*—Wheat—Toria.

As appreciable quantities of farmyard manure are applied to the preceding maize or cotton, *senji* needs no more manure.

The crop is ready for cutting when in full flower and after seed formation has started. The green fodder is available in January, February and March. It forms an excellent fodder for draught cattle and milch cows, but should be chaffed and fed mixed with *bhusa*, or some other dry fodder, as otherwise it is apt to cause tympanitis. It yields about 250 *maunds* of green fodder per acre. When matured for seed the yield is about 8 *maunds* per acre. Its price is same as that of wheat.

A new selection known as Fo. S. I. has recently been evolved in the Punjab. It gives a more uniform stand and a higher yield than the existing crop.

There is another species of *senji* (*Mellilotus alba*) which is grown in some places as a late crop. It is white-flowered. It can provide green fodder as late as April but is slightly bitter. Its yield per acre is generally less than that of common *senji*.

METHA

Natural Order—*Leguminosæ.*

Botanical Name—*Trigonella foenum-graceum.*

English Name—*Fenugreek.*

Metha is one of the leguminous *rabi* fodders. It is more drought resistant than *senji, berseem,* etc. and can, therefore, be *grown under restricted conditions of irrigation.* Its fodder is nutritious but is considered to reduce the milk yield when fed to milch cattle in large quantities. It is chiefly grown in Ludhiana and Ferozepur districts in standing crops of cotton just like *senji*. It is not fastidious in its soil requirements and can be grown on all types of soils but like most other crops does well in rich loams. The total area under this crop is estimated to be about one lakh acres.

Seed is broadcasted and covered by a *khurpa* hoeing if it is sown in *vattar* in standing crop, otherwise broadcasting is followed by irrigation like *senji*. The seed rate is 16-20 *seers* per acre. Sowing time extends from October up to mid-November.

It is ready for feeding in about 3 to 4 months after sowing *i.e.*, in February, March. Ordinarily it gives only one cutting. Its yield is about 250 maunds of green fodder per acre.

If kept for seed it is harvested in April and gives an average outturn of 6 to 8 *maunds* per acre. The seed sets well and there is no difficulty in its production. The seed is used as a medicine besides being used in the preparation of pickles.

BERSEEM

Natural Order—*Legumiuosæ.*

Botanical Name—*Trifolium alexandrinum.*

English Name—*Egyptian clover.*

Berseem, apart from American cotton is probably the only recent exotic introduction into the husbandry of the province that has become very popular with the cultivators. It is known as Egyptian clover because it is extensively grown in Egypt, where out of a cultivated area of three million acres one million is returned as *berseem*. In India it was first introduced in Sind. It flourishes there well and considerable areas are grown, notably at Mirpurkhas and Hyderabad. From Sind it was brought to the Punjab where after numerous trials for several years it was recommended to the cultivators. It established its worth very soon and its cultivation spread very fast. It is estimated that within a decade of its introduction with the zamindars it has come to occupy an area of about one *lakh* acres.

Like *senji* it is leguminous and enriches the soil. The very high yield per acre of Egyptian cotton is said to be largely due to the fertilising properties of *berseem*. It has tender succulent leaves and is highly relished by all kinds of livestock. It is especially suited to milch cattle because it is believed to improve their milk yield. The fodder is very rich in protein. Its yield also is higher than *senji*. In comparative trials it has given three times the yield obtained from *senji*. The average yield of green fodder is about 500 to 600 *maunds* per acre but in very rich soils yields of the order of 1,000 *maunds* per acre have been obtained. In short both from the points of view of quality and quantity of fodder it is superior to *senji* and indeed most other *rabi* fodders which therefore it is replacing at a fairly rapid rate. *Berseem* can replace *senji* in the ordinary rotation of crops except that sugarcane cannot be grown after it, because it occupies a field for a longer period than *senji*. It can be successfully grown year after year in the same land but usually it follows cotton and maize.

It yields 3 to 5 cuttings and provides a regular supply of green fodder from December to May. Thus it helps to tide over to a certain extent the two periods of scarcity of green fodder during the year (December and April-May).

Soil and cultivation.

It does well in most soils provided they are retentive of moisture. Rich loam soil is, however, the best. In order to get good results a fine seed bed should be prepared.

Time and method of sowing.

The sowing of *berseem* usually commences from the middle of September and continues up to the middle of November. In hotter parts of the province sowing should be delayed up to the end of September as in the case of earlier sowings the tender seedlings get killed by the intense heat. Probably one of the reasons for sowing *berseem* in cotton and maize crops is that their plants provide shade to the young seedlings growing underneath.

The seed is soaked in water for about 10-12 hours and then broadcasted on a moist seed-bed. Harrow and *sohaga* are subsequently used for covering the seed. The seed may also be broadcasted in a dry seed-bed which may be watered after harrowing. But the best results are obtained by broadcasting seed in standing water like *senji*. *Berseem* seed often contains *kasni* (chicory) but it can easily be separated from it. The mixed seed is put in five per cent. salt solution and *berseem* seed being heavier settles down while *kasni* being lighter floats on the surface. It can then be easily removed.

Seed-rate.

Eight-ten seers is quite sufficient for an acre. When sown alone the first cutting gives low yield. *Senji* or oats are, therefore, usually mixed with it to increase the yield of the first cutting. In this case 5 to 6 seers of *berseem* with 20-24 seers of *senji* or oats are sown.

Inoculation.

Like other leguminous crops *berseem* can fix atmospheric nitrogen through the agency of a certain type of bacteria which form nodules on the roots. If these bacteria are absent from the soil little nitrogen is assimilated and the plants remain stunted and sickly. *Berseem*, therefore, generally does not do well when sown in a field for the first time on account of the absence of these bacteria. This handicap can be removed by the inoculation of the soil with the required bacteria and there are two ways of doing this. Firstly, soil (taken after removing the top three inches) from a field which has already borne this crop may be broadcasted in the field at the rate of 2 to 4 *maunds* per acre. Secondly, specially prepared culture for this purpose may be utilized. These cultures are obtainable in three sizes from the Agricultural Chemist, Lyallpur. Their present prices are given below:—

	Rs.	a.	p.
Full size	1	0	0
Half size	0	11	0
Quarter size	0	8	0

One full size culture is sufficient to inoculate seed for one acre. This culture is mixed with about half a *seer* of 10 per cent. sugar or *gur* solution. The liquid is then sprinkled over seed heaped on a gunny bag or on a clean floor and mixed with it thoroughly. The seed is then dried in a thin layer in shade. The treated seed should not be kept for more than 24 hours before sowing as drying lowers the viability of the bacteria which may ultimately be killed if seed is not sown for an unduly long period. The sun is also very harmful to them and the treated seed should, therefore, be sown either in the evening or on a cloudy day.

Experiments conducted with the sowing of inoculated and uninoculated seed showed that the former yielded about 86 per cent. more fodder than the latter. There is no need of inoculating a field where *berseem* has once been grown. Similarly, a field which has borne *shaftal* need not be inoculated as the organism connected with it is capable of benefiting *berseem* also.

Irrigation.

A light irrigation should be given about a week after sowing in order to ensure satisfactory germination and to give the crop a good start. Thereafter irrigations may be given whenever required—usually after an interval of a fortnight. During winter the interval may be prolonged, while in April-May it has to be reduced on account of heat. Frequent irrigations are given to the crop reserved for seed during the flowering and seeding stages.

Time of cutting.

The first cutting can be obtained late in December or early in January and subsequent cuttings at monthly intervals.

Seed production.

The main obstacles in the spreading of the *berseem* in this province is the difficulty in securing its seed. The local production is rather small and the seed requirements are at present chiefly obtained from the North-Western Frontier Province. In recent years, however, the demand has been so great that it has not been possible to meet it fully. Attempts are now being made, therefore, to encourage its production locally. When seed is required not more than two or three cutting should be taken. In any case no cutting should be taken after the middle of March, otherwise the seed produced will be poor and the yield low. Good seed should be bright yellow and plump, free from all weed seeds, the commonest of which is *kasni* (chicory). To keep out *kasni* seed roguing of this weed plant should be scrupulously done. The crop reserved for seed is ready for harvesting about the end of May or early June. The seeds are borne in thick set inflorescences. When the amount of seed to be produced is small the inflorescences may be picked with hand and the seed beaten out. But when these operations are to be carried out on a larger scale harvesting may be done by means of a sickle and the threshing by bullock labour. An acre yields about 4 *maunds* of seed. The price of seed was Rs. 20 per *maund* before War. During 1944 it rose to Rs. 60 per *maund*. Plots reserved for seed should be preferably selected in a sheltered place to afford protection from hot winds when setting of seed is in progress.

Much useful work has been done at Lyallpur in connection with the production of sound seed with good germinating capacity. An analysis of several samples commonly used for sowing has shown that the *berseem* seed is of three colours, yellow, red and brown. Fully-matured seed is yellowish in colour with germinating capacity of over 80 per cent. as against 50 and 25 for red and brown seeds respectively. With a view to ascertain the effect of different number of cuttings on the yield of seed and the colour of seed the experiments were conducted at Lyallpur. The results are given below:—

Sample.	Yield per acre.		Percentage germination of mixed seed.	*Percentage of seed of different colours.*		
	Md.	Sr.		Yellow.	Red.	Brown.
No cutting taken ..	4	29	91·0	78·0	17·0	5·0
One cutting ..	3	12	82·0	72·0	20·0	8·0
Two cuttings ..	1	2	61·0	63·0	21·0	16·0
Three cuttings ..	0	36	29·0	38·0	30·0	32·0

cuttings can be obtained during a year. All kinds of livestock take it with avidity but it is specially valued as a green fodder for horses and is, therefore, grown largely near cantonments and remount depots. The total area in the Punjab under Lucerne is about 42,000 acres.

It can be grown on all types of soils free from water-logging, but it does best in well drained loams.

Seed is sown at the rate of four to six seers per acre at any time during the cold weather but the best time is from middle of October to middle of November. It is rather difficult to get reliable seed. Good seed should be plump, glossy and rich brown in colour. It is, however, advisable to conduct germination test to ascertain the reliability of the seed. A well-prepared fine seed bed is essential to obtain good yields. Several methods of sowing are in vogue, the most common being broadcasting seed on a moist seed bed. The seed may also be drilled in lines one foot apart. It has, however, been discovered that sowing on ridges 1½ feet to 2 feet apart gives best results. In this manner water can also be economised and hoeing facilitated. When sown on flat, the crop sometimes gets killed in low lying spots where water stagnates. Thus bald patches appear in the field. These can be removed by resowing seed in the patches. The crop should be hoed frequently to keep down weeds.

The first irrigation should be given about three weeks after sowing and regularly at similar intervals subsequently also during the winter. During summer, however, the interval should be reduced to a fortnight.

It is advisable to apply well-rotted farm yard manure at the rate of 10-15 cartloads per acre about a month before sowing. To keep up good yields throughout, application of manure is essential, probably, after every third cutting.

About 600 *maunds* of green fodder is generally obtained per annum. The yield deteriorates after the first year if manuring and hoeing is not done.

Seed is best produced in the spring season. No cutting is taken after February from the plot reserved for seed. To encourage seed formation, water is sparingly applied and withheld altogether as seed ripens. The crop is ready for harvesting at the end of April. Only about 2 to 3 *maunds* of seed per care may be expected. Seed production in the case of lucerne is even more difficult than in the case of berseem. It is available from Messrs. Nathu Ram and Sons, Neemuch, Central India, and Messrs. P. Pocha, Poona.

TEOSINTE.

Natural Order—*Graminaceæ.*

Botanical Name—*Euchlaena mexicana.*

Vernacular Name—*Makchari*

Some botanists consider teonsinte to be the wild ancestor of maize. Like maize, it favours a hot and humid climate and does well under conditions of good rainfall or liberal watering. The soil must also be rich and well manured. If sown in March or April, on such soil two to three cuttings of green fodder can be obtained starting from May or June depending upon the time of sowing. If, however, it is sown late in July-August, the crop gives only one cutting and is ready in October-November, when there is scarcity of fodder. Twelve to 16 *seers* of seed are required to sow an acre. The sowing may be done either by broadcasting the seed and ploughing it in, or by *kera*. It can also be sown mixed with leguminous crops like beans and peas. The crop is seldom given any inter-culture. Three to four irrigations are supplied. The plants tiller profusely and give rise to a number of shoots forming a thick clump. Under favourable conditions the height may reach up to 12 feet. Yields of 400 *maunds* and above have been obtained. The fodder is succulent and nutritious and is relished by all kinds of cattle. The seed ripens in November. Unlike maize where a compact cob is produced, the female inflorescence in this crop consists of a number of strings of seeds covered by glumes and borne at the nodes. The harvested seed is allowed to dry for a fortnight or so before threshing.

A good crop may yield up to 15 *maunds* of seed per acre. The colour of the ripe seed varies from creamy white to dark brown. Immature seeds, although of normal size are, white in colour and much lighter. So far teosinte has not been observed to have been attacked by borer or any fungus diseases. In this respect it is superior to maize and *juar*. This crop has been recently introduced in the Jullundur Division.

COWPEAS.

Natural Order—*Leguminosæ.*

Botanical Name—*Vigna sinensis. Endlicher.*

Vernacular—*Rawan.*

The cowpea is not a pea but a bean commonly cultivated for human food. It is also a valuable fodder crop. It is adapted to almost the same climatic conditions as maize but requires slightly warmer climate and is a little more drought resistant. It does as well on sandy soil as on heavy clay, and can withstand moderate shade, and, therefore, does well when grown in mixture with tall plants like maize.

The best time for sowing is the middle of March though it can be sown later also, some-time even up to the end of July. The seed-rate is 20 to 25 *seers* per acre when broadcasted. When sown in rows 5 to 10 *seers* and by *kera* 12 to 15 seers are sufficient. The first irrigation is given three weeks after sowing when germination is complete. After the second irrigation, which is given about two months after sowing, the crop is ready for feeding. Average yield of fodder per acre is 250 to 300 *maunds*. For the production of seed the crop should be sown in July. Normal yield is 5 to 7 *maunds* per acre. The pods of cowpea can also be used as green vegetable for human beings. Out of the varieties tried in the Punjab cowpea F.O.S. No. 1 has proved to be the best. It matures its first pods in 70 days. It is a half bushy and winy plant with straw-coloured pods and seeds covered with minute blue specks.

VELVET BEANS.

Natural Order—*Leguminosæ.*

Botanical Name—*Stizolobium deeringianum.*

Vernacular Name—*Makhmali Sem.*

It requires medium to light loamy soils. As the seed is very big and hard it requires a little more moisture for germination than other legumes. Twenty seers of seed will be enough for an acre, but care should be taken that seed is not buried very deep, otherwise, the cultivation is similar to that of cowpeas, except that the yield of grain is heavier, *i.e.*, 15 *maunds* per acre. The seed from unripe green pods is used as vegetable. It forms a very good mixture with teosinte. Eight to 10 *seers* of each gives good results.

SOYABEANS

Natural Order—*Leguminosæ.*

Botanical Name—*Glycine hispida.*

The cultivation is similar to that for cowpeas. The seed rate is 12 to 15 *seers.* A moist climate is more suitable for soyabean but crops can be grown in drier parts under irrigation. Three to four irrigations must be given before the crop is ready. A crop will yield 200 *maunds* of fodder per acre when sown alone. In case of mixture higher yield is obtained. When matured for seed, yield is about eight *maunds* per acre.

JAPAN RAPE

Natural Order—*Cruciferæ.*

Botanical Name—*Brassica napus.*

Vernacular Name—*Japan sarson.*

Japan rape, as a green fodder, is grown where either no irrigation can be given or only a limited water supply is available. It can be grown on all types of soils but the best results are obtained on good loamy soils. It is sown in September-October, the early sowings being best for *barani* areas. Rate for fodder is about three *seers* per acre. Otherwise the cultivation is similar to that of *toria*. The crop is ready for feeding in the middle of December and can be fed up to the beginning of February, when it flowers profusely. Out of all the rape varieties, white-leaved Japan rape gives the highest yield of fodder and also of seed with high oil content, on all types of soils. It is called white leaved because the colour of the leaves is much lighter than the other Japanese variety, which is called black leaved. The second best of all the rapes as regards fodder yields is *raya*. Average yield of green fodder per acre may be taken at 300 maunds though yields up to 400 *maunds* have been recorded. Its flowering stalks provide a very palatable vegetable (*sag*), which is very much enjoyed during winter. When mature for seed it ripens about the middle of March and gives eight to ten *maunds* of seed per acre. At Sirsa an outturn of 17 *maunds* per acre has been obtained.

GUINEA GRASS

Natural Order—*Graminaceæ.*

Botanical Name—*Panicum maximum.*

It is a perennial plant and continues to give green fodder for many years. It is finer leaved and more nutritious than Napier grass and also more palatable. It does best under warm and moist climate. In the Punjab therefore, it is grown where plentiful irrigation supply is available. It is generally grown near the main water courses, as it is easy to water under such conditions.

Propagation.

Guinea grass ears normally in the Punjab but the seed does not ripen properly and its viability is extremely poor. It is, therefore, propagated by planting root stocks, which are broken up into individual units, each of which is capable of giving rise to a new plant. The sets are planted at a distance of 2 to $2\frac{1}{2}$ feet each way and 7,000 to 10,000 units will be required to plant an acre. The field is irrigated immediately after planting. To complete sprouting, second irrigation should be applied after two to three weeks. Subsequent irrigations may be given as required. The best time for planting is the beginning of spring, *i.e.*, the first fortnight of February. In order to get good yield the field should be kept clean of weeds by occasional hoeing.

The first cutting is taken 2½ months after planting, and subsequent cuttings can be had after about every two months throughout summer. The interval will, of course, vary with the fertility of soil and irrigation available. About five cuttings can be taken during the year, giving a total yield of about 500 *maunds* per acre. Guinea grass would give good outturn for about six years if adequate manuring and interculture are given.

RHODES GRASS

Botanical Name—*Chloris gayana.*

This is also a perennial plant and continues to give good yield for three years after which it requires a change of soil. It does best in hot and moist climates. Rhodes grass ears normally but seed does not ripen at one time. The collection of seed is, therefore, a very laborious process, because the ripe seed sheds immediately after ripening. Its viability is also very low. It is, therefore, advisable to propagate it vegetatively from root stocks, which are planted 1½ to two feet each way. 10,000 to 15,000 stools are required for an acre. Planting can be done any time during the year but February plantings give the best results. The grass is ready for feeding two months after planting. Subsequent cuttings can be taken after about every month until severe cold sets in. Seven to eight cuttings in all can be obtained giving a total yield of 400 *maunds* per acre. The growth is very luxuriant during the rainy season.

ANJAN GRASS

Botanical Name—*Pennisetum Cenchroides and*

Cenchrus Biflorus,

There is a very large number of pasture grasses in the Punjab. Out of all these *Anjan* or *Dhaman* grass has done best under cultivated conditions. There are two species, each species having two varieties differing in the colour of seed as given below.

1. White hairy *Anjan* 2. Purple hairy *Anjan*	*Pennisetum cenchroides.*
3. White non-hairy *Anjan* 4. Purple non-hairy *Anjan*	*Cenchrus Biflorus.*

Of these No. 1 has done best as regards yield and its ability to give early herbage in spring.

The chemical analysis has shown that green *Anjan* grass is the most nutritious of all the Punjab grasses. Provided the soil is suitable it produces fair crop even with a rainfall of 14 inches and it does well with 20 inches rainfall. Under irrigation it is sown in March-April but under *barani* conditions the seed should be broadcasted with the break of monsoon. Eight to ten *seers* of seed are enough for an acre. Seed is set throughout the year but best seed is produced after the rainy season—September to October. Under favourable conditions two to three *maunds* of seed per acre is produced. It gives good yield for two years. Like other grasses it is ready for cutting every month in the rainy season.

The total area under different beans for fodder is about 15 thousand acres. The area under different types of rapes grown for fodder is 150,000 acres.

SUDAN GRASS.

Botanical Name—*Andropogon sorghum Var. Sudanesis Piper*

Sudan grass is an annual plant closely related to common *juar.* The panicle is, however, loose and open, glumes are awned and flowers are often purple in colour. The colour usually fades to pale yellow when ripe and the awns are broken during threshing, so that cleaned seed rarely has awns. It tillers profusely, 100 stalks arising out of one crown being not uncommon. It does well in warm climates and can produce fair crops in regions of low rainfall. It does best on rich loam. No manure is required when soil is reasonably good. On alkali soils yield is reduced markedly. It can be grown mixed with cowpeas, soyabeans and other legumes. The best time for sowing is middle of March. It can be sown either by broadcast or by *kera.* Ten to 12 *seers* of seeds per acre is sufficient. Usually the first cutting is ready in seven to ten weeks, depending upon soil and moisture and subsequent cutting can be had on an average after every 1½ month. In all four cuttings yielding 400 to 600 *maunds* of green fodder can be obtained. On account of slender leafy stems and sweetish taste, it is relished by cattle, horses and sheep. It can also be dried as hay. For seed the crop when ripe may be harvested and stacked in small bundles, from which penicles when dry may be cut and threshed. Under favourable conditions three to five *maunds* of seed may be obtained from an acre. As sudan grass crosses freely with other sorghums, it would be advisable either to grow a plot specially meant for seed in a place where there is no *juar* field nearby or to produce it from the ratoon crop maturing seed in April and May, because no other sorghum flowers at this time. Sudan grass is subject to the same pests and diseases as *juar.*

NAPIER (ELEPHANT) GRASS

Botanical Name—*Pennisetum purpureum.*

Vernacular Name—*Hathi ghas.*

It is a perennial grass which gives very high yield of fodder. It does best in hot and moist climates though fair crop can be raised under dry farming conditions as well. It can be grown on all kinds of soils, provided they are well drained, but best results are obtained on fertile loams. It needs no manuring in the beginning, but when it has been on the field for more than a year and a number of cuttings have been taken farmyard manure should be added. Napier grass does not set seed in the Punjab, though it flowers quite freely. The canes and rootstocks of the plants are, therefore, used for planting. The cuttings can be planted in two ways. The sets may either be sown in moist land like sugarcane in furrows 2½′ to 3′ part with similar distance between sets in furrows or stuck into the field thoroughly prepared and levelled at an angle of 45°

or so at distances of $2\frac{1}{2}$ to 3 feet from plant to plant and row to row, so that one bud is above the ground and the other buried in the soil. In the latter case field should be irrigated immediately, whereas in the case of former no immediate irrigation is to be applied but the field should be irrigated 10 to 15 days after sowing when young shoots appear above ground. In case root stocks are to be planted, they are broken into small lumps and dibbled into seed-bed at distances mentioned above. In irrigated lands the best time for planting is middle of February and in *barani* areas with the outbreak of monsoons. 7,000 cuttings or root-stocks are required to plant an acre if distance between plants and rows is $2\frac{1}{2}$ feet. The number of cuttings required would be less if the distance is increased. The first cutting is ready within three months and then at intervals of $1\frac{1}{2}$ to $2\frac{1}{2}$ months depending upon time of sowing, fertility of soil and irrigation water. The canes should not be allowed to grow coarse and thick, otherwise cattle would leave large amount of wastage. It can give four to six cuttings in a year yieding 600 to 1,000 *maunds* of green fodder, though yields as high as 1,500 *maunds* has been obtained.

Napier grass is somewhat fibrous and is, therefore, not such a good fodder as some other fodder crops and grasses are. No pest or disease has so far been found to attack this grass though it is very susceptible to frost.

References.

(1) Fodder crops of the Punjab by H. R. Saini.

(2) Department of Agriculture, Punjab's Leaflets Nos. 49, 66, 92, 96, 97, 98, 108, 136, 140 145, 147, 159, 174, 187 and 193.

(3) A Summary of the more important results arrived at or indicated by the Agricultural Stations and Research Officers in the Punjab—1930-31 to 1934-35 and 1935-36 to 1937-38— Department of Agriculture, Punjab.

(4) Experiments at the Lyallpur Agricultural Farm, January 1930.

(5) Reports on the Season and Crops of the Punjab.

(6) Administration Report of the P.W.D. (Irrigation Branch Punjab—1941-42.)

CHAPTER XVIII

MISCELLANEOUS CROPS

TOBACCO

Natural order—*Solanaceæ.*

Botanical name—*Nicotiana tabacum. Nicotiana rustica.*

Vernacular name —*Tambaku.*

Tobacco is an annual cultivated plant, excepting, in Mexico and tropical countries, where it is perennial. It can be grown in almost all kinds of climate. In the cold and temperate regions, it is grown as a summer crop and in other countries as a spring crop. In India, tobacco appears to have been introduced in the reign of Akbar, by Europeans who visited his court.

Area.

For the quiquennium ending 1942-43 the total area under this crop was 71,115 acres, which constituted only about 0.23 per cent. of the total area sown in the Punjab. Of this nearly 98 per cent. or 69,743 acres was irrigated and the rest unirrigated. During 1943-44 there were only 32,745 acres under tobacco. This huge reduction in tobacco area was due to the imposition of excise duty at the rate of one anna per lb. from 1st April, 1943, on *hukka* tobacco. The duty was increased to three annas per lb. from March 1944. This resulted in the sharp rise of prices. The wholesale harvest price in 1941-42 was Rs. 8-12-0 a *maund*. In 1942-43, it rose to Rs. 19-1-0 and in 1943-44 it went up to Rs. 42-1-0. With the rise in prices it is expected that there will be an appreciable increase in the area which may reach the normal figure or even exceed it.*

The most important districts growing tobacco in this province are Jullundur, Attock, Sialkot, Sheikhupura, Gujranwala, Gujrat, Montgomery, Lyallpur and Jhang, though it is grown on a small scale by Muslim and Hindu

Since the above was written, the figures for 1944-45 is available, which is 3,352 acres.

cultivators almost all over the Province. During 1943-44 there were only four important districts, *viz.*, Lyallpur, Multan, Jhang and Attock growing a little over 2,000 acres each.

Classification.

The classification of tobacco is based on the uses to which it is put, *viz.*, (*a*) *hukka* tobacco, grown for smoking in *hukka*, (*b*) cigar wrappers, the outer leaves of cigar, (*c*) cigar fillers, leaves placed in the interior of cigars, (*d*) pipe tobacco, (*e*) chewing tobacco, (*f*) plug tobacco, (*g*) cigarette tobacco and (*h*) snuff tobacco. In the Punjab mainly *hukka* and snuff tobaccos are grown.

There are several varieties of them. Broadly speaking they can all be divided into two classes: (1) Nicotiana Tobacum or *desi* (2) Nicotiana Rustica or *gobhi* or *balkhi*. The first class includes a large number of *desi* types, and is characterised by medium height, medium thickness of the main stem and long and tapering leaves. All of them can further be classified into 4 groups: *noki*, *kakkar*, *ghhora* and *gidri*.

In the case of *gobhi* types, the plants are again of medium height, but their stem is thin, leaves are orbicular with highly puckered surface, inflorescence is compact, flowers are yellow and the capsules are small and round. There are two sub-types of it: *gobhi* and *Calcuttia*.

Desi tobaccos are all used for smoking in *hukka* whilst those in the second class, *i.e.*, *gobhi* type for both *hukka* and snuff, as they are considered to be more strong and pungent than those belonging to the first group. Recently a start has been made with the cultivation of cigarette tobacco as well.

Soil.

Tobacco can be grown on almost all types of soil. But for successful cultivation it requires a well drained loamy soil containing a fair amount of organic matter and rich in mineral matter, especially potash. On heavy soils or heavily manured lands, heavier yields are obtained, but the leaves become coarse and inferior in quality. Light soils rich in organic matter and retentive of moisture produce better tobacco for making cigars or cigarettes.

Preparation of land.

The land for planting tobacco should be thoroughly cultivated by giving 4 to 6 ploughings in order to obtain fine tilth. A month before planting, about 40-50 cartloads of farm yard manure per acre should be thoroughly mixed in the soil. Where sufficient amount of farm yard manure is not available, sheep folding may be done with great advantage. In connection with manuring it must be remembered, that heavy application of manure gives excellent results in the case of *hukka* tobacco, but in the case of cigarette tobacco manuring must not be heavy, for otherwise the quality of leaves will be affected. It has been observed that about 8 tons or 10 cartloads of farm yard manure are quite sufficient. In addition 150 lbs. of potash and 100 lbs. of superphosphate may be applied. This will improve the growth of the plant as well as the flavour and burning qualities of the leaves.

Nursery.

Tobacco seed is sown in nursery in October and November. The seed hed is very carefully prepared and manured. The seed mixed with dry earth in order to ensure uniform distribution, is then scattered over the bed and lightly covered up with earth. Since the seed is very small, it should not be sown deep. About one *chhatak* of seed sown in half a *marla* of land is quite sufficient for raising seedlings for one acre. After sowing the nursery beds are carefully irrigated.

Transplanting.

When the seedlings are about 4-5 inches high they are transplanted into the field prepared for this crop. It is important to irrigate the nursery beds 8-10 hours before removing the seedlings for transplanting as it will facilitate the removal of seedlings without damaging their roots. The seedlings are planted in rows 3 ft. apart in the case of cigarette tobacco and 1½ ft. apart for *hukka* tobacco with distance from plant to plant as 2′ and 1½′ respectively. The field should be watered immediately after transplanting and again in well areas on the following afternoon. The transplanting should be done in the afternoon, because by doing so the plants will get the advantage of high humidity and low rate for tanspiration during night. In the central districts of the Punjab, it has been found that early March is the best time for transplanting.

Interculture.

Weeding and hoeing are very essential for this crop so as to conserve soil moisture and create conditions suitable for the easy penetration of young and delicate roots. Since tobacco has its main feeding roots fairly close to the soil surface, it is essential that the first two hoeings should be shallow and carefully done. Weeding may be done whenever necessary.

Irrigation.

In plains generally 7-10 light irrigations are generally applied. The crop should be irrigated when there is positive need for water, the best time for which is considered to be when wilting of plants is observed in the forenoon. If there is no wilting the soil moisture conditions may be considered to be good. Excessive irrigation will cause the leaves to become coarse and poor in aroma and flavour.

Topping.

When flowers begin to appear, it is necessary to cut off the tops especially in the case of *hukka* tobacco. It will enable the plant to devote all its energy to the development of leaves and give "strength" to them. Topping is done 3-4 times at intervals, depending upon the character of soil, manuring and variety. In the case of cigarette tobacco, topping should be done only when the leaves are very thin. If, however, the growth is excessive and the leaves have a tendency to become coarse and dark green in colour the plants may be allowed to develop flowers. The idea in doing this is to allow the plants to divert some of the food material to the flowers and keep the leaves thin and pale green.

Harvesting.

The crop transplanted in early March will be ready for harvest by about the end of May. The maturity and condition of the leaf is, however, the best guide for the correct time of the harvest. When the crop approaches maturity the leaves become thick and brown flecks appear on the surface. When harvested at the proper time the woody portion of the stem at the cut end will be brown.

In the case of cigarette tobacco, harvesting of leaves at the correct stage of ripeness is of special importance for otherwise the quality will be impaired. If the leaf is unripe, it will retain its green colour, whilst overripe leaf will turn yellow during early stages of curing and finally turn brown. The correct time for harvesting is when the leaf is just turning yellowish green.

As the tobacco leaves ripen one by one in a regular order starting from the lowest to those near the top, the picker must go over the field from time to time. Picking of leaves must be done in the later afternoon when the temperature has fallen or early in the morning before it gets hot. The leaves should be handled carefully to avoid breakage and should be placed under shade.

Curing.

In the case of *hukka* tobacco, the leaves are left in the field for drying. They are turned next morning when the leaves are slightly flacid. Drying is carried on for two to three days. For curing the plants are collected in the morning and are heaped on a pucca floor or in a pit lined with straw on sides and bottom. The heap is covered with old gunny sheets and is kept as such for about a week or ten days. The completion of the process of curing is indicated by a particular smell. The leaves are then taken out of the pit and made into ropes which are afterwards dried in shade.

In the case of cigarette tobacco, curing must be done in properly-constructed barns under controlled conditions of humidity and temperature. This is called flue curing method and gives leaves of good colour and quality. The cured leaves may then be graded according to colour and size and and made into "hanks" which are bulked on wooden platforms for fermentation. This develops the characteristic odour and aroma of a good tobacco.

Yields vary considerably from district to district. The highest yield is obtained in Attock—30 *maunds* per acre while lowest yield is obtained in Muzaffargarh where it is only $6\frac{1}{4}$ *maunds* per acre. The average yield of *hukka* tobacco in the Punjab may be taken to be about 12 *maunds*, though under favourable conditions it may give even 30 *maunds* per acre. In the case of cigarette tobacco, the average outturn is about 15 *maunds* per acre.

Yield.

The average total production of tobacco in this province is about 11 *lakh maunds.* Of this about 20 per cent. is retained by the growers for home consumption. About 50,000 *maunds* are used in the manufacture of snuff amounting to about 35,500 *maunds.* This valued at Rs. 20 per *maund* gives a little over seven *lakh* of *rupees.* The balance of the crop is sold in the market.

The total crop of the province is not enough to meet the needs of the province and about 286,000 *maunds* are, therefore, imported every year. Of the total imports about 1/3rd comes from N.W.F.P. and Delhi and the remaining 2-3rd from other places. These imports include about 6,200 *maunds* of tobacco valued at Rs. 43,700 required for the manufacture of cigarettes. The annual production of cigarettes in the Province is about 5,000 *maunds* valued at Rs. 3,06,000. It may be mentioned that the cigarettes produced are only of cheap quality manufactured from low quality tobacco. In addition to this about 37,000 *maunds* (corresponding to 26,000 *maunds* net) of manufactured tobacco are imported. Of this, 81 per cent. are cigarettes, 12 per cent. *biris*, 4 per cent chewing tobacco, 2 per cent. pipe and cut tobacco and 1 per cent. cigars and "cheroots". About 50 per cent. of these imports are received by Shahdara Imperial Tobacco Co. for distribution. The *hukka* type tobacco is imported from N.W.F.P., U. P., Bombay and Sind, while the cigarette tobacco is all imported from Guntur (Madras Presidency). *Biris* are mostly imported from Delhi and Madras, while chewing tobacco is obtained from Rampur State, Lucknow, Moradabad, Cawnpore and Benares. Cheroots are obtained from Trichinopoly in Madras Presidency, pipe and cut tobacco from Bombay and Karachi, and cigarettes from Bombay, Calcutta, Delhi and Karachi.

The total exports of *hukka* tobacco amount to 96,000 *maunds.* Of the cigarettes manufactured locally about 50 per cent. valued at Rs. 1,70,000 are exported mostly to U.P. and a little to Punjab States and the remaining 50 per cent. is consumed locally. Similarly, 50 per cent. of the snuff manufactured is also exported, mostly to Sind and a little to U.P., Bahawalpur and Kashmir States, valued at Rs. 3,50,000.

Snuff is mostly used by the low class illiterate people. It is made of different colours. Yellow colour is preferred in the Punjab while green, yellow and black are more popular in Sind.

Manufacture.

(1) *Cigarettes*—For a desired blend, definite proportions of different grades of tobacco leaf are mixed. All then are chopped very fine and mixed thoroughly. The following ingredients are further added. The recipe followed by one factory is given below :—

(1)	Tobacco mixture	1 *maund*
(2)	Molasses	4 *seers*
(3)	*Malathi*	½ *seer*
(4)	Common salt	½ *seer*

In the case of high-quality cigarettes molasses are replaced by glycerine.

(2) *Hukka Tobacco.*—The dry leaves are beaten with wooden pestle and sifted through a very coarse sieve. To this, varying quantities of adulterants such as common earth imported from Hazro, and other ingredients such as molasses etc. are added. Though the recipe varies with each manufacturer yet the following recipes of *karwa* tobacco will give a rough idea of the ingredients used and their amounts :—

(1)	Tobacco stalks crushed	1 *maund*
(2)	Common earth imported from Hazro	2 *maunds*
(3)	*Sajji*	2½ *seers*
(4)	Molasses	1 *maund*

In case of *desi* tobacco common earth and other adulterants are not used, but only tobacco leaves are used. For instance, (1) Powdered *desi* tobacco 1 *maund*, and (2) Molasses 30 *seers*. The prices of various tobaccos are :— *kala karwa* Rs. 4 per *maund*, and *desi* Rs. 5 per *maund*.

(3) *Snuff*.—The tobacco plants are dried and leaves are separated from the stalks. The leaves are then crumbled into small pieces and ground into powder by a power-driven mill. This powder is then soaked in water for about 15 days, during which time it ferments. The fermented stuff is called *khamir*, which when dry is ground with a wooden pestle and mortar, and then sifted through cheese-cloth. To this powder, certain ingredients are added and thoroughly mixed. After this, required quantity of lime solution is added. The whole mass is then ground again and sifted through cheese-cloth. This grinding and sifting is repeated till the product attains the desired stage of fineness. It is then packed in tins and is ready for the market. The formulae and the recipes for making snuff vary with the manufacturers and are kept secret. The recipe used by one manufacturer in Hazro is given below :—

(1)	*Khamir* (fermented tobacco flour) ..	1 *maund*
(2)	Slaked lime	2 *seers*
(3)	Butter	½ *seer*
(4)	Almond Kernels	½ *seer*
(5)	Black pepper	¼ *seer*
(6)	*Jaifal*	¼ *seer*
(7)	Ammonium chloride	1 *chhtk.*
(8)	Red pepper	½ *chhtk.*
(9)	Perfume, rose or *keora* ..	2 ozs.
(10)	Dye or desired colour ..	According to requirements.

The chief snuff-manufacturing places are Hazro (Attock district) and Alipur (Muzaffargarh district) in order of merit, while small quantities are also manufactured at Multan, Rawalpindi and Dera Ghazi Khan.

Research.

With a view to selecting high-yielding varieties of *hukka* tobacco and exploring the possibilities of growing cigarette tobaccos in the province, research work was started by the Punjab Agricultural Department in 1931. Since then, experiments on various strains of tobacco, both imported and indigenous, have been carried out. Out of the several *hukka* tobacco strains so far tried, type No. 12 has been selected. Similarly, of the cigarette varieties, type No. 57 has given excellent results. The results of curing experiments on this type show that a good quality cigarette tobacco can be produced in the Punjab. The problem of curing is also receiving due attention. For this purpose two flue curing barns had been erected at Lyallpur and Jullundur.

In 1944, an Indian Central Tobacco Committee was formed on the lines of Indian Central Cotton Committee to deal with the improvement of tobacco crop. It is expected that comprehensive research schemes will soon be started on tobacco.

Cost of production.

The cost of production of a good crop of *hukka* tobacco is given below :—

	Rs.	A.	P.
Preparatory tillage	9	0	0
Farm Yard manure (45 cartloads) 50 per cent.	22	8	0
Seedlings	1	8	0
Transplanting	1	8	0
Hoeings and weeding	6	0	0
Watering (8 @ Rs. 3 per irrigation) ..	24	0	0
Toppings (4 @ Rs. 2-8 each)	10	0	0
Harvesting	2	8	0
Rent	15	0	0
Land Revenue	3	8	0
Total ..	95	8	0
Gross income :—			
Tobacco 30 *maunds* @ Rs. 4 per *maund*	120	0	0
Stalks 30 *maunds* @ 0-4-0 per *maund*	7	8	0
Total	127	8	0
Net income	32	0	0

The cigarette tobacco sells at the rate of Rs. 20 to 30 per *maund*, and gives a gross return of about Rs. 350 per acre. Since the cost of curing comes to about Rs. 125, the net income in this case would be about Rs. 130 per acre. This means a net gain of about Rs. 100 per acre in growing cigarette tobacco as compared with *hukka* tobacco.

In recent years, the export of Virginia tobacco from India to the United Kingdom has considerably increased. In 1934-35 these exports amounted to 9·3 million pounds and in 1937-38 these figures were more than doubled. It is hoped that as a result of research to be shortly undertaken under the Indian Central Tobacco Committee, Punjab will begin to grow Virginia tobacco and will then take its due share in the exports.

INDIGO

Natural Order—*Leguminosæ.*

Botanical Name—*Indigofera tinctoria.*

Vernacular Name—*Nil.*

Indigo is grown for the sake of the dye which is extracted from its leaves and branches. Its cultivation in the Punjab is limited to only a few South-Western districts such as Multan, Muzaffargarh, and Dera Ghazi Khan, though a few odd acres are also met with here and there in other districts, particularly in Ambala, Karnal Hoshiarpur, Jullundur, Lahore, Gurdaspur, Gujrat Montgomery and Lyallpur. The manufacture of artificial dye has almost completely killed this industry. Before the 1st Great War, the area under this crop fluctuated between 20,193 acres and 66,802 acres. During the war it attained the peak figure of 90,837 acres in 1917-18. After the war it fell precipitately, varying in twenties between 6,440 acres and 50,492 acres. In thirties it never rose above 11,332 acres and in fact in one year (1934-35) it was as low as 2,999 acres. The area in 1943-44 was only 4,392 acres. Of this 4,270 acres were irrigated. The crop is largely grown on the inundation canals in the *kharif* season.

The seed is generally sown in March-April, though it is sometimes sown in the rains also. In the latter case it is left to give a ratoon crop the following summer. The March-April crop is cut in August. If the land is not ploughed up, new shoots appear and a crop of seed is obtained in December. As a rule a *rabi* crop follows the indigo and the latter being a legume improves the soil.

Indigo requires loam to heavy loam soil. Generally no manure is applied and 2 to 3 ploughings are sufficient to prepare the land for sowing. Seed is sown broadcast at the rate of two to three *seers* on a moist seed bed and covered by a *sohaga*. It is important to keep the crop free of weeds. Generally two weedings are given and three to four irrigations are sufficient.

Generally two cuttings are taken and for the extraction of dye the plants are fermented in vats. The process of dye manufacture followed in the South-Western districts is somewhat as follows* :—

The crop is usually harvested in the morning and put into a couple of water tanks in the afternoon. Each tank contains about four *maunds* of green plants which are weighed down with a heavy weight so that they are completely immersed under water, where they are kept for about twelve hours or so when they begin to produce a peculiar sound known only to the experts. This denotes that the dye has been dissolved out from the plants, which are then taken out of the water. The greenish water left contains the dye for the precipitation of which the water is vigorously stirred for about three hours with the wooden rake. It is then allowed to settle and water is drained off. To remove the water completely the dye is first taken to a small trough where it is kept for 24 hours and the water taken off; then it is put on a piece of *khaddar* cloth spread over a layer of sand which serves as an absorbent of moisture. The mass thus produced is then thoroughly dried in the sun for about two days and sold in the bazaar in small lots.

The yield of dye is about 30-40 *seers* per acre.

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*Farm Accounts in the Punjab 1931-1932 by S. Kartar Singh and S. Arjan Singh—Publication No. 32 of Board of Economic Inquiry, Punjab.

TEA

Natural Order—*Ternstroemiaceæ.*

Botanical Name—*Camelia Thea.*

Vernacular Name—*Chai.*

Tea is the most widely used beverage in the world. It is taken only as a stimulant, as it contains negligible food value. The stimulating properties of tea are due to the presence of caffeine. Dry tea leaves contain on an average 3·5 per cent of caffeine. In addition to caffeine, tea contains about 12 to 15 per cent. Tannin which gives tea its colour and is responsible for the taste and astringency. Though China is the oldest tea-producing country and cultivated the tea plant for centuries together before any country had even knowledge of it, yet as tea has been found growing wild in Assam, the general opinion is that India is the original home of tea.

The cultivation of tea in India was taken up in 1833 in Assam and first consignment of Indian tea was put for public sale in London in 1839. From Assam the tea gradually spread to other suitable areas in India. In the Punjab, it was grown for the first time in the Kangra hills in 1849. As the tract selected was very suitable for tea planting the area rapidly increased to 1,254 acres in 1854, 7,266 acres in 1881 and 9,537 acres in 1892. Since then the area has remained more or less the same, the figure for 1943-44 being 9,183 acres.

Climate and Soil.

As the life of tea plant is over 100 years, the proper selection of planting site is of paramount importance. The first consideration for the selection of site is the climate. Tea requires warm and moist climate, with plenty of rainfall well distributed throughout the year. Long droughts and heavy frosts are dangerous for the tea plant. In the Kangra valley, average annual rainfall in the tea-bearing tract is about 100". The second factor which should be considered in establishing a tea plantation is that of soil. Light, rich, friable and well-drained soil is the best. A light soil is to be preferred to the clayey one. The sub-soil is also of great importance as it affects proper drainage and the development of tap roots. Water-logging has ruinous effect on the plant.

There are two methods of sowing tea :—

Sowing.

1. Sowing the seed in the nursery and then transplanting.

2. Sowing seed in situ.

For nursery the seed is sown on beds 6 to 9 inches apart in the spring. It germinates after a month or so. It remains in the nursery for about 15 months. Then it is transplanted to the permanent places during rains. In the case of sowing in situ, seeds are directly sown in the permanent places. Of the two systems of planting the nursery system is considered to be better, as it affords a chance of selecting good plants. The distance between plants varies from 3 feet to 5 feet. The field is laid out before planting and small pits $1 \times 1\frac{1}{2}$ feet are made at places where the plants are to be planted and filled with some manure and earth. Tea is generally grown on slopes. The slopes are terraced to stop erosion.

The tea plant comes to bearing 3 years after transplanting. During this period it receives manure and cultivation. Once the plant is established it does not require any watering.

The yearly programme of work of a tea garden is as under :—

November to January	..	Pruning.
February to March	..	Manuring.
April to October	..	Plucking and Manufacture.

Pruning.

Pruning is the process of cutting those leaves and branches which are not required for the proper yield of tea leaves If these are not removed then the plant runs to seed, and the output of leaf decreases. The plants should receive the first pruning when they are two to three years old. This should be cut as far back as 10 to 12 inches from the ground leaving only the main stem and a few shoots as breathers. Next year the bush is pruned about 8 inches above the previous cut and so on till the bush attains a decent size (not over $2\frac{1}{2}$ ft. in Kangra) and healthy growth. It is to be seen that the bush develops a broad flat surface, so that the plucking of leaves can be done easily.

Manuring.

As tea is a leaf crop, it requires large dressings of nitrogenous manures for rapid growth. A mixture of farm yard manure and sulphate of ammonia is ideal for tea crop.

Plucking of leaves.

The nature of plucking depends upon the quality of tea that is to be manufactured from the leaves. For making high-grade tea, only the finest shoots consisting of the bud and two leaves are plucked. Plucking is done by hand and a labourer can pluck 10 to 12 lbs. of leaf in a day. The plucking starts from about the month of April. This is the first flush and gives the finest tea. With each successive flush, the quality of tea falls off. There are 4 to 5 flushes in all in the season. Close and hard plucking are to be avoided. Close plucking means early removal of every leaf that can possibly be plucked. This is sometimes done to increase the outturn at the sacrifice of quality, but it is not good for the bush itself. The leaves after plucking should be collected in the basket and kept in the shade. If exposed to sun or collected in a heap, fermentation would start. The leaves should be carried to the factory as soon as possible.

Tea manufacture.

Two kinds of tea are made from the leaves: (1) green and (2) black. In the case of green tea, the leaf is immediately heated in iron pans for 3 to 5 minutes, but in the case of black tea, the leaf is spread out on withering racks. The leaves are then taken to the rolling machines for rolling. The object of this process is to bruise the withered leaves, so as to enable the cell juices to become mixed and also to give a curl-like twist to the leaves. As old leaves do not get the proper twist in rolling ; these should, therefore, not be plucked if high grade tea is to be made. This rolling is common to the manufacture of both kinds of tea. In the case of green tea the leaf after rolling is finally dried quickly, but for manufacturing black tea the rolled leaf is allowed to ferment for 3 hours in a dark cool place. During this process some of the tannin is oxidised and gives the black tea its dark brown colour. The leaves are then brought to the drying machine in which hot air circulates. Drying stops the process of fermentation. It should be completed quickly, otherwise the tea would develop a bad smell due to over-fermentation. The tea is then cleaned of all foreign matter, which may have got in during process of manufacture and graded by means of sieves. It is then carefully packed so as to leave no scope for tea to absorb moisture from atmosphere. On smaller estates, where proper drying machinery cannot be used, all these processes are done by hand, by drying the leaves in the open pans placed on fire.

Yield.

The yield per acre of manufactured tea was only 168 lbs. At present it varies in Kangra between 200 and 300 pounds, as against 750 pounds of North-east India.

Market.

Kangra tea being poor in quality has never been well received at Calcutta auction, as it cannot stand competition with Assam tea. For this reason mostly green tea is produced in Kangra. The planters here sell all their tea to the dealers in Amritsar, who export it to Kashmir, Afghanistan, Persia and Central Asia. The gerneral rate before the War was only six annas per pound. Now-a-days it is about twelve annas per pound.

The chief tea-producing countries in the world are India, Ceylon, Netherland East Indies, British East Africa, China, Japan and Formosa. In the pre-war years the exportable surplus of tea from the different tea-producing countries was 1,105 million pounds. Pre-war consumption of tea in the important countries was 890 million pounds ; the excess being 215 million pounds. The result was that the prices began to fall and huge surplus stocks began to accumulate in all countries. The potential excess of production over consumption necessitated some sort of control in regard to this commodity. An international agreement was concluded in 1933 between India, Ceylon and Dutch East Indies. Under this agreement these countries decided to restrict the export of tea to about 66 per cent of their average production.

Within India, every tea estate is awarded yearly export quota rights based on the production of that estate by the Indian Tea Licensing Committee, constituted under section 3 of the India Tea Control Act of 1933. If a tea producer sells his tea locally and does not export it, he can sell his exporting right to another producer. There is a regular market for the export licences. As the Kangra tea planters are not exporters of tea, they sell their export licences. The income from the sale of these licences has helped tea industry considerably. This scheme has proved very beneficial in raising price of tea in the markets of world, which had fallen from Re. -/11/4 per pound in 1928-29 to Re. -/5/2 per pound in 1932-33. After the international agreement came into operation in 1933 the price rose to Re. -/9/7 per pound in 1933-34, and Re. -/11/5 in 1939-40. As against this the average price of tea for internal consumption was Re. -/4/4 per pound.

Work done by the Agricultural Department.

The Agricultural Department started a Tea Experimental Farm at Palampur in 1939. The main line of work was the rejuvenation of deteriorated tea plants and their upkeep. The deteriorated plants were given proper manuring, pruning and plucking on scientific lines. Results obtained from these experiments show that the yield of tea from the rejuvenated plants can go up to 600 pounds per acre. The results of these experiments are now being followed by most of the tea gardens in the Kangra valley. There is a great scope for improvement in the manufacture of tea as the correct method of manufacture of tea in Kangra is very little understood at present. It is, therefore, suggested that the Agricultural Department should set up a small experimental plant for finding out the most economical and efficient method of manufacturing high quality tea.

MEHNDI

Natural Order—*Lythreceæ.*

Botanical Name—*Lawsonia alba.*

English Name—*Myrtle or Henna.*

Not very long ago *mehndi* like Indigo was an important money crop in the Punjab, particularly in Gurgaon district. Owing to the production of chemical dyes, however, indigo industry has almost disappeared, but *mehndi* cultivation still persists, and is an important money crop in Gurgaon District, especially round about Faridabad.

Soil. It grows in almost all types of soils ranging from light loam to clay loam. It can tolerate even a little of alkalinity in the soil, but it does best on heavy soils, which are retentive of moisture.

Five *seers* of seed is required to plant an acre. The actual method of soaking the seed in Faridabad is as follows :—

About three *seers* of washed and cleaned *mehndi* seed is put in an earthen pot. An equal amount of water is added to it. At the bottom of each pot a hole is provided, which is loosely closed with a piece of wood, so that water may slowly tickle down through this opening. The seed is shaken every morning and fresh water is added to fill the pot. This process is continued for 10 to 15 days till the seed sprouts. This soaking of seed is done from early March to the end of April.

The sprouted seed is sprinkled on the nursery beds, which have been well prepared by ploughing and adding well-rotted farm yard manure at the rate of 300 *maunds* per acre. These beds are irrigated before seed is sown. The seed is then covered with powdered dung to avoid damage from sun, etc. The seedlings are fit for transplanting in July, when they are pulled out of the nursery and planted in the field after cutting out the tiny roots and shoots, so that the plant may remain erect at the time of transplanting. The distance from plant to plant is about 1 foot. Transplanting is not done in regular rows. The plants can also be raised from cuttings. Waterings are given according to the needs. In a year of normal rainfall which is about 25 inches in Gurgaon district, 4 to 5 waterings—2 to 3 in summer and 1 to 2 in winter are enough for the whole year.

The crop requires occasional hoeing and weeding.

Harvesting.

It is harvested twice a year. The first cutting of leaves and branches is taken in October, and the yield is about 15 *maunds* of dry leaves per acre. This is the major crop. A nominal cutting is taken in January when only tiny shoots, which would otherwise be killed by frost, are removed. The second cutting is taken in the month of May. This is not as heavy as the October harvest, and the yield is only 4 to 5 *maunds* per acre. Thus, the total annual average yield is about 20 *maunds*.

During the first two to three years after planting the yields are light and vary from 2 to 10 *maunds* per acre. The crop has got a very long life and lasts for years. There are fields, which had been planted over 100 years back, and are still giving good outturn, as they have been well attended to.

The powdered leaves of *mehndi* (henna) are used for dyeing hair by men and staining hands, feet, fingers and nails by women. Henna is also used in colouring leather and in making other dyes, and extensively employed as a medicine. Its leaves form a valuable external application in the case of burns, scalds, skin diseases, prickly heat, etc., and the bark is given in jaundice and spleen enlargement. Decoction of leaves is used as an astringent. The adulteration of *mehndi* is quite common, the usual adulterant being sand ground with green dye and mustard oil. It can, however, be easily detected by dissolving the stuff offered for sale in water. If sand has been mixed it will settle down and oil would give an oily appearance to water. Sometimes leaves of other shrubs are also ground with the *mehndi* leaves. In that case detection of adulteration is rather difficult.

Mehndi is exported from Faridabad to nearly all important towns and cities of India, especially those in Ajmer Marwar. Small quantities are also exported to the adjoining countries as well as to the United States of America and the Continent of Europe, where it is used in the preparation of dyes and toilet articles.

Cost of cultivation.

According to pre-war rates, the non-recurring expenditure per acre is about Rs. 185, while recurring expenditure is about Rs. 70. Taking the life of the crop to be 10 years, the total cost in the whole of this period comes to Rs. 185 plus Rs. 630, *i.e.*, Rs. 815, or Rs. 80 per acre per year. Income on the basis of 20 *maunds* of dry leaves per acre at Rs. 6 per *maund*, comes to Rs. 120. This leaves a net income of Rs. 40 per acre, which is quite high, particularly in comparison with that for other crops. Some farmers also obtain additional income by planting lemon and mango plants in the *mehndi* fields.

MUSHROOM.

Natural Order—*Agarcaceæ*,

Botanical Name—*Agaricus campestris.*

Vernacular Name—*Khumb.*

Mushroom is frequently met with in many parts of India. In the Punjab it appears after the rains in some fields and the desert areas of the central and Southern districts. It is frequently eaten after cooking as a vegetable and is also extensively dried for future consumption. In the West, mushroom culture has attained great importance. In the U.S.A. alone, about 17 million lbs. are produced annually. It is extensively used in the manufacture of ketchups, gravies and curries. Since mushroom provides an excellent nutritive food it is also quite common there to give it to convalescents. There is a considerable scope for the developing of this industry in the Punjab and Bahawalpur State. Trade between the Punjab and the Western countries could also be easily developed in case high quality mushrooms are grown on a large scale in this province.

Some varieties of mushroom commonly called as "toadstool" are poisonous and if eaten may cause death. Very great care is, therefore, needed for gathering mushrooms from the open fields. Although the distinction of poisonous from non-poisonous fruits is not an easy task and can best be done only by experienced persons, yet it can be stated that the best forms of edible fungi are those, which when young are like round white buttons and when they open out, are like umbrellas with gills (underside) of delicate pink colour. Poisonous types are likely to turn yellow when cooked. Fungi having slimy skin or when broken or bruised show an intense blue colour, shonld be avoided.

Although mushrooms are met with in the open fields quite commonly in some seasons of the year, yet it is not easy to produce them successfully in the fields on a commercial scale. Mushrooms are very sensitive to conditions of temperature, moisture in the soil and humidity. Absence of sufficient rains, unexpected cold or high temperature may altogether kill the crop. It is for this reason that in Western countries, mushroom is grown under controlled conditions in mushroom houses, cellars and caves. In the East, Burma was the first to introduce the artificial cnltivation, as it is possible to produce mushroom there throughout the year, provided the minimum temperature does not go below 70°F, though in some of the Western countries, the most favourable temperature is considered to be 54°F with a range of 50°F to 60°F. The culture used in Burma took 15 to 17 days to mature. Madras has reduced the period from 13 to 15 days. Artificial mushroom is grown there on the paddy straw, though horse-dung in alternate layers with good friable soil upto a depth of 3 ft. can be also used for this purpose. In the case of paddy small bundles of paddy straw weighing about three pounds each, $3\frac{1}{2}$ to 4 feet flat and 10 inches in diameter, are taken. These bundles are soaked in clean water and kept under water for 24 hours. Four straw bundles are kept side by side over a raised platform of bricks or planks with the loese end towards one side and another four bundles are placed similarly, but with the loose end towards the opposite side. These eight bundles form one layer of the bed. Pure culture bottle spawns of ½″ to 1″ thickness each, are placed on the bed four to five inches from the edge all round, 4 inches apart and 1 inch deep, and a dessert spoon of powdered red gram *dal* is sprinkled on the spawn (the vegetative stage of the fungus in a suitable substratum such as rich earth, horse dung, moist leaves of trees, etc.) Powdered gram husk, containing broken bits of *dal*, will also serve the purpose. The reason for using *dal* powder is that the fungus having no green colour called chlorophyll is unable to synthesise carbohydrated food and so ready-made food is provided to give it a start. A second, third and fourth layer may be formed in a similar way. The whole bed is pressed to make it compact and watered immediately with a rose-can and kept just moist. It is watered once a day and mushrooms begin to appear in about 13 to 15 days after spawning and continue for about 4 to 5 days. A second crop may be expected after a week. The total yield varies from six to ten pounds of mushroom per bed. These mushrooms can be grown at home handy for some delicious dishes. The bottle spawn can be had from the Government Mycologist, Coimbatore, at a nominal price. The Government Mycologist, Punjab Agricultural College; Lyallpur can also supply spawn and full directions to those interested. In the Punjab climate they should be kept in air-tight tins in a cool place. The imported mushrooms can be cultivated even in the hilly districts.

POPPY.

Natural Order—*Papavaraceæ.*

Botanical Name—*Papavar somniferum.*

Vernacular Name—*Post.*

Poppy is grown only to a small extent in a few districts of the Punjab. Before the 1st Great War, the area under this crop ranged between 2,000 and 9,000 acres. In the year 1943-44, it was only 1,113 acres. Of this 443 acres were grown in Hoshiarpur and the rest in Jullundur.

Poppy plant requires a rich loamy soil with abundance of moisture. Usually 3 to 4 ploughings are sufficient for the preparation of land. The land should also be well manured at the rate of about 16 cart-loads per acre. The crop is usually sown in the month of October or beginning of November. The seed rate is about $\frac{1}{2}$ to 1 *seer* per acre which is sown broadcast on a moist seed bed. For even distribution of the seed it will be better to mix an equal quantity of sand with the seed before broadcasting. About two to three weedings are quite sufficient. Water should be applied as and when needed. Light irrigations after about every 2 to 3 weeks would be necessary in the growing period. The capsules begin to swell in March and towards the end of the month an estimate of the probable yield can be framed. The traders come forward for buying the standing crop at this time. The crude opium is obtained by making vertical incisions on the capsules about $\frac{1}{2}''$ in length. These incisions are given 3 to 4 times on each capsule, and the operation extends over a fortnight or so. The incisions are usually given in the middle of the day so that heat may assist the exudation of the juice and the following morning the crude opium is collected. About ten men are necessary to incise the capsules and collect the juice from an acre of land in a day. Since this is carried on for 3 to 4 times, this operation is quite expensive. The produce obtained from an acre varies from 4 to 10 *seers*. The average may be taken to be 6 *seers* per acre.

Poppy cannot be grown by a farmer without obtaining a licence from the Government. While opium is used as narcotic, its seeds are extensively used by sweet-meat makers or in the manufacture of certain curries. The oil obtained from the seed is also largely eaten or used for culinary purposes. The best seed is obtained when the the capsules have not been incised for the extraction of opium. In some parts the leaves and the petals of flowers of young plants are sometimes eaten as a salad.

INDIAN HEMP.

Natural Order—Urticaceae.

Botanical Order—*Cannabis sativa.*

Vernacular Name—*Bhang*.

Bhang grows wild in many parts of the plains of India. In the Punjab, it is largely met with in the lower hills and sub-montane districts under wild conditions though it is grown on a small scale as a cultivated crop in Dera Ghazi Khan and Jhang. The total area under cultivated crop was only 27 acres in 1942-43 and 17 acres in 1943-44.

The Indian hemp plant is valued for *charas*, *ganja*, and *bhang*. Whilst *charas* is manufactured largely in Nepal, Kashmir, Ladakh, Afghanistan and *ganja* in Bengal, C.P. and Bombay, *bhang* is largely derived from wild plants in the Punjab, N.-W.F.P., and Madras. In Europe, particularly in the central and southern Europe, the plant is cultivated for fibre and seeds are eaten or crushed for oil. In the mountains of upper India, though *fibre* is sometimes obtained from this plant and used for weaving into garments or twisted into ropes, the chief use to which this plant is put to is that of obtaining *charas* or resinous substance exuded by the plant after spontaneous rupture of the bark just before the maturing of flowers. This is also found on the young leaves, flowers and fruits. In the plains the plant is found not to exude the resin in this way, but instead the narcotic goes into young female flowers and twigs. These constitute the *ganja*. If male plants are allowed to remain in the field the female flowers get fertilized and the *ganja* is destroyed, and the narcotic properties not developed until fruit is fully matured. Leaves at this stage along with the fruit constitute *bhang*. It is thus obvious that climate, soil and mode of cultivation affect the plant and its properties to yield different types of Indian hemp products.

The cultural practices differ greatly according to the uses to which the plant is put. In the case of cultivation for narcotics, rich friable loam is selected in a moist but not shady place. About 4 to 10 ploughings are necessary for the preparation of seed bed. The preparation for raising nursery generally commences with the first shower of rain and is continued till about the end of August. The seed is then sown by broadcast and when the seedlings are about 6" to 12" high they are ready for transplantation. The seedlings are transplanted 6" to 8" apart. In November the lower branches of the plants should be trimmed so that the upward growth of the plant is stimulated. When the plants begin to come in flowers, services of an expert are called in who cuts down the male plants. Even a few male plants left in the field may injure the entire crop because they will run into seed and *ganja* yielded will be of inferior quality. Of course, for the preparation of *bhang*, the plants are allowed to get fertilized and much care is not needed.

For the production of fibre, which is not a common practice in India the seed rate is usually high. The growth of better fibre is promoted by thick sowing. For this purpose, after preparing the land, the seed is sown in November and cut by the end of March. Clay soils are considered to be the best. The plants when ready are harvested and are retted under water and fibre is extracted like sann hemp.

TUNG.

Botanical Name—*Aleurites cordata.*

Tung oil being an excellent drying oil is an important ingradient of paints and varnishes. At one time China had a monopoly of this oil, with U.S.A. as the chief importer. During the last 20 years, however, the latter has been able to grow this plant quite successfully, though even now she imports about 1½ million *maunds* of this oil from China out of a total production of 3¾ million *maunds*. The world consumption of tung oil is about 10 million *maunds*.

In view of great importance of tung oil, efforts have been made by the Punjab Agricultural Department to grow this plant in Kangra district where the climate is suitable for it. In 1938, one pound seed of Montana and one pound of Fordii varieties was obtained from the Chief Scientific Officer of the Indian Tea Association, Assam. It was planted at Tea Farm Palampur in January 1939. The plants raised were transplanted in the Farm in January 1940. Five pounds of seed were obtained in February 1940 and 185 plants raised from this seed were distributed to five tea estates near Palampur. The plants in the Tea Farm began fruiting in 1943, *i.e.* in the 4th year from transplanting. Montana variety did well, the others failed. Some of the fruit on the chemical test was found to contain 68.32 per cent. of oil on dry basis in the kernel which is considered to be very satisfactory.

Plants given to the Tea Estates began fruiting in 1944. Yield per plant in the Tea Farm in the 5th year from transplanting is two pounds per plant, but is expected to go up to ten pounds or even more as the plants grow.

All the seed produced in 1943 at the farm was used for multiplication. In addition, Dharamsala Tea Estates obtained some seed on their own account and started sowing it. The total number of plants distributed by them and the seed from which is being utilized at present for further multiplication is about 1,300.

Tung prefers a loose soil, the type found round *khads* which is not fit for any other crop and is generally classed as waste land. There is plenty of such land in Kangra district, hence a great scope for the extension of its cultivation. Moreover, Tung does not require any elaborate care.

The plantations under way would be producing about 500 *maunds* of fruit by 1950 even at a conservative estimate of 10 pounds per tree which should be possible for the industry to utilize in the Punjab.

References.

1. Report on the Marketing of Tobacco in the Punjab (Unpublished.)

2. Seasons and Crop Reports of the Punjab.

3. Punjab Agricultural Department Leaflet No. 99.

4. Farm Accounts in the Punjab, 1931-32, by S. Kartar Singh and S. Arjan Singh.

5. Tea Industry in the Punjab, Gurditt Chand M. A.

6. Dictionary of Economic Products by Watt.

7. Bailliére's Encyclopaedia of Scientific Agriculture, H. Hunter.

8. Field and Garden Crops—D. Milne and Ali Mohd.

9. Report on Chinese Agriculture by S. B. S. Kartar Singh (Unpublished.)

CHAPTER XIX

GENERAL OBSERVATIONS.

So far in this book we have discussed the technical side of agriculture, mentioning the present methods of cultivation with suggestions for improvement, with a view to increase the net income of the cultivator, either by improving the quality or the yield or both, of the produce, or by reducing the cost of cultivation by using improved methods. It is felt that by tenchnical improvements, as mentioned above, agricultural production can be increased possibly by 25 per cent. This is, however, not possible because all the technical improvements cannot be introduced to their best advantage, unless some other drawbacks, which stand in the way of introduction of improvements, are removed. It is proposed to discuss these points in this chapter as these could not be conveniently discussed elsewhere.

Pressure of population on land.

The population of India in 1941 was 389 millions. It is increasing at the rate of 1.5 per cent per annum which would give a population of about 564 millions in 1971.

Land per person.

In British India the area under cultivation is 259 million acres. Add to this the culturable waste other than fallow—92 million acres. This gives only 1.1 acre per adult person on the basis of present (1946) adult population of 313 million. In 1971 with adult population of 423 million it will be only 0.8 acres per person. The population of British Punjab was 28½ million in 1941. The area under cultivation is 31 million acres. Adding 14 million acres of cultivable waste other than fallow it comes to 1.44 acres per person on the basis of present (1946) population of 31⅓ millions and 1.91 acres per adult person. The problem is, thus, not so urgent in the Punjab as in India as a whole, though, the higher rate of increase in the Punjab so far is half a million a year, *i.e.* 2 per cent per annum indicates that it will soon be on a level with the rest of India. It must be remembered that the so-called cultivable waste is largely useless unless irrigation and other amenities are provided. This will naturally take considerable time even if it is at all feasible in some areas. American workers calculate that 1.2 acres per head are required for emergency restricted diet and 3.1 acres to provide a liberal diet. It is not, therefore, surprising if Indian nutrition experts estimate that 30 per cent of India's population is underfed quite apart from consideration of quality. Dr. Akyroid estimates that India on the whole requires 20 per cent more calories chiefly from grains, 15—20 per cent more pulses, 10—20 per cent more sugar, 100 per cent more vegetables and 200 per cent more vegetable fats and oils.

War policy.

In the face of all this the war policy of the Government of India whereby every effort is to be made to increase the milk and ghee supplies seems to ignore fundamental facts. It is a scientifically established fact that an acre of irrigated land grown with grains and vegetables can support larger population than when it is devoted to milk production. The table below gives the food units per acre when different commodities are grown.

Comparative calorific value per acre of staple food, vegetable and oil seed crops and milk.

Crop	Yield per acre in pounds (Edible portion)	Calorific value. Per pound	Calorific value. Per acre
Wheat (whole) excluding straw ..	1,316·6	1,566·7	2,062,717·2
Potato ..	9,051·1	450·4	4,076,750·6
Cabbage ..	16,457·1	152·0	2,501,479·2
Mustard seeds (*toria*) ..	658·3	2,421·5	1,613,624·9
Berseem fodder used for milk production.	49,200.0 producing 4,820 lbs. of milk.	314·0	1,544,880·0

Yield per acre taken at :—

				Calorific value per 100 grammes
(1)	Wheat	.. 16 *maunds*	..	345.4
(2)	Potato	.. 110 *maunds*	..	99.3
(3)	Cabbage	.. 200 *maunds*	..	33.5
(4)	Mustard seed (*toria*)	.. 8 *maunds*	..	540.4
(5)	*Berseem* used for milk production	.. 600 *maunds*	..	66.8 106.1

Note : One pound = 453·6 grammes.

As regards milk the food units consumed before the cow is in milk, *i.e.*, up to 3 years of age must be taken into account. If we deduct this, the nett gain may be about 1 million calories. Berseem, of course, will require much more water than wheat.

This very point is clearly made out in the table below which gives the food consumption and land required for producing it in Germany and Great Britain before the war.

Article of food.	Food consumption pounds per head per annum (P. Lamartine Yates).		Land required for production of British levels of yield acres.	
	Great Britain	Germany	Great Britain	Germany
Bread and flour ..	197	222	0.15	0.16
Potatoes ..	210	398	0.015	0.03
Sugar ..	109	56	0.04	0.02
Beef and veal ..	66	34	0.40	0.31
Pork ..	48	65	0.18	0.25
Mutton and other meat ..	29	..	0.26	..
All meat ..	143	100	1.04	0.56
Milk (gallons) ..	20	21	0.06	0.06
Butter ..	22	16.4	0.18	0.14
Margarine ..	8	15.5	..	..
Cheese ..	9.5	12.6	0.02	0.03
			1.50	**1.00**
		Other foods	**0.1**	**0.05**
			1.60	**1.05**
Percentage of sufficiency ..			**40 or less**	**84**

The main theme is that Germany using potatoes 398 lbs. (compared to 210 in United Kingdom), half the sugar, 100 lbs. of meat, of which 65 per cent is pork as compared to 143 in United Kingdom, can support one human being on 1 acre whereas United Kingdom required 1.6 acres. The figures are for 1937. "The ideal dietary for a policy of self-sufficiency must be physiologically adequate and require the minimum of land for its production.[1]" One acre of potatoes produces at least twice as much food as one acre of wheat.

Beef as produced in United Kingdom takes 12 lbs. of dry matter to make one pound of meat and is, therefore, very wasteful. It is usually estimated that milk production secures one pound of dry matter from 5½ pounds of food. This indicates milk production also is wasteful, though twice as economical of land or of food as meat. Russel states further that it is dangerous to produce vitamins where calories are deficient.

Until India is producing enough calories to feed the population the agricultural effort should be concentrated on production of grain, potatoes or similar products supplemented by vegetables for the necessary vitamin supply. It must be recognised that milk production is wasteful though more efficient than meat production. It is only when sufficient calories are being produced for human consumption that our surplus should be devoted to highly processed foods such as meat and milk.

An all-India policy may not, and in fact often does not, suit individual farmer but should be based on a sound scientific basis for the country as a whole.

Until, therefore, the main food producing problems are solved, it would seem wise to concentrate on (*a*) vegetables, (*b*) grains (*c*) pulses and (*d*) oilseeds. Considered from this point of view milk and ghee are luxuries which India as a whole can ill afford. The relative price of milk

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1. Paper by Dr. E. J. Russel (*Chemistry and Industries Journal* June 5th, 1943).

compared to other food is far too low if the cost of production is borne in mind, except, perhaps, in places specially favourable for milk production, such as, river *belas*, vast areas of uncultivated land as in Karnal district, and big forest areas. Besides, crop farming on the whole gives higher profits than milk production as shown from the data given in the appendix.

Another characteristic feature of the Indian population is, that a major portion of it is rural, mainly depending on land for subsistence. According to 1941 census, 87 per cent of the population was rural and only 13 per cent urban. The corresponding figures, for the British Punjab were 85 and 15 per cent. respectively. The proportion of urban to total population in some other countries is as follows :—

United Kingdom ..	.. 1931	80 per cent.
Netherland ..	.. 1930	48 per cent.
France ..	.. 1926	48 per cent.
U. S. A. ..	.. 1820	7 per cent.
	1870	26 per cent.
	1930	56 per cent.

The heavy pressure of population on land, naturally, results in low income per capita for the rural population.

Total income from Agriculture.

Findlay Shirras in 1921-22 estimated total income from agriculture to be at Rs. 226.3 *crores* for the Punjab and Delhi. Professor Brij Narain gives a figure of Rs. 131.4 *crores* in 1925-26. The Board of Economic Inquiry Punjab—Publication No. 52 gives a figure of Rs. 96.23 *crores*. A rough estimate for 1940-41 given below gives a total of Rs. 101 *crores* :—

Value of Agricultural produce in the British Punjab, during the year 1940-41 :—

Crop	Estimated outturn	Harvest prices		Total value
		Per *maund*	Per ton	
	'000 tons	Rs. a. p.	Rs.	'000 Rs.
Rice ..	462·7	2 7 0	66·4	30,723.28
Wheat ..	3,388·9	3 0 0	81·8	273,122.02
Barley ..	219·3	2 1 0	56·2	12,324.66
Jowar ..	98·1	2 11 0	73·3	7,190.73
Bajra ..	477·4	2 9 0	69·8	33,322.52
Maize ..	447·8	2 9 0	69·8	31,256.44
Gram ..	699·7	3 0 0	81·8	57,235.46
Rabi Oilseeds ..	176·6	4 0 0	109·0	19,249.40
Sesamum ..	7·1	7 0 0	190·8	1,354.68
Gur ..	470·4	3 5 0	90·3	42,477.12
Cotton (Desi) ..	318·2	5 4 0	143·1	45,534.42
Cotton (American) ..	350·3	7 2 0	194·2	68,026.26
Tobacco ..	24·1	7 9 0	206·1	4,967.01
Other Millets ..	30·0	2 8 0	55·4	1,662.00
Pulses ..	225·0	5 0 0	136·3	30,667.50
Groundnut ..	140·0	3 8 0	95·4	1,355.60
Fruits and Vegetables ..	..	..	..	32,822.90
Hemp ..	14·4	8 0 0	218·0	3,139.20
Fodders (green) bhusa and stalks ..	..	..	..	314,014.94
			Total ..	1,010,428.14

Taking 100 *crores* as a safe figure and the total rural population at 24·7 millions this gives an income per person of Rs. 40-8-0 only. This is well below the average for India given by economists as Rs. 65 per capita. In recent years, owing to war-prices, the average income in say 1944-45 is estimated as about Rs. 100 per rural inhabitant. This figure is much below what industrialists in cities like Bombay conceive as the Punjab income. As buyers of our surplus foodstuffs they imagine the province to be rolling in wealth.

Fragmentation of holdings.

The law of *inheritance* requires *equal partition* of ancestral property among male heirs. Owing to the difference in the quality of the land it often leads to the division of each field, so that say four brothers inheriting after a father who owned 5 fields may each have 5 small fields instead of 1¼ each. Such fragmentation leads to great inefficiency. There is enormous waste of labour, both human and bullock in reaching the various fields. More land is wasted under field embankments which have necessarily to be made round the fields. It also stands in the way of sinking wells for irrigation and keeps back cultivators from living on the land, which results naturally in lower yields. Consolidation of holdings has been attempted in 14 districts by the Cooperative Department since 1920 on voluntray basis. The total area consolidated is 1.5 million acres. This work is also being done by the Revenue Department under the Consolidation of Holdings Act passed in 1936, which is applicable to 8 districts. The area consolidated is 3 *lakh* acres. It is proposed to extend its application to other districts as well. It is hoped to expand this work and thus increase the pace under the post-war development plan. Under the existing Act consent of 66 per cent of land-owners is necessary to start operations in a village. It should accelerate the pace of consolidation if this is reduced to 50 per cent. It is, however, felt that the progress will be slow, and can only be a palliative until the law of inheritance is changed.

Size and distribution of holdings.

The term "holding" has been very much misunderstood and has, therefore, given rise to much confused thinking. An attempt is, therefore, made here to describe it more clearly.

There are three different types of holdings: (1) owner's holding, (2) cultivator's holdings, (3) one-plough holding.

Owner's holdings.

The land is generally held by a body of village proprietors whose shares are determined by ancestral relationships. According to rule of inheritance each son usually gets an equal share. Mr. Calvert was the first in this province to study this point and the results of this inquiry were published in 1925. The table below gives the detailed figures.

Table showing number of owners' holdings according to area of cultivated land owned :—

Size		Holdings		Area	
		Number.	Percentage to the total.	Estimated No. of acres.	Percentage of total area cultivated.
Under 1 acre	..	625,400	17·9	313,00	1·0
1—3 acres	..	908,400	25·5	126,800	4·4
3—5 acres	..	520,000	14·9	1,935,000	6·6
5—10 acres	..	630,600	18·0	4,400,000	15·1
10—15 acres	..	288,300	8·2	3,353,000	11·5
15—20 acres	..	150,100	4·3	2,444,000	8·4
20—25 acres	..	94,000	2·7	1,967,000	6·8
25—50 acres	..	168,700	4·8	5,887,000	20·4
Over 50 acres	..	120,900	3·3	7,452,000	25·7
Total	..	3,506,400	99·6	27,877,800	99·9

It will be observed that 17.9 percent of owners own less than 1 acre each and the total area owned is only 1 per cent of total; 40.4 per cent of owners own over 1 acre and less than 5 acres and the area owned is only 11 percent of the total. Three fourths of the total number of owners possess under 10 acres each and $\frac{1}{4}$th of the total cultivated area, whereas the remaining ¾th is owned by ¼th of the owners. The percentage owning over 25 acres is 8.1 only and accounts for 46.1 per cent of the area. Only 3.3 per cent owners own over 50 acres each but this accounts for about 25.7 per cent of the area. Only one person out of every eight owns any land at all. For the province as a whole, the average size of owner's holding is 8 acres. This is reduced to 4.6 acres if owners holding over 25 acres are left out. For the sake of comparison the sizes of holdings in some other countries are given below :—

U. S. A.	140 acres
Canada	Over 100 acres
Great Britain	64.1 acres
France	28.8 acres
Denmark	38.5 acres
Germany	24.1 acres
Czechoslovakia	20.0 acres
Italy	15.4 acres
Rumania	14.9 acres
Netherlands	14.3 acres
Belgaria	13.3 acres
Yugoslavia	13.0 acres

A similar inquiry was conducted by the Board of Economic Inquiry Punjab in 1939 to see if any change had occurred during the 15 years period. The results are reproduced below :—

Size of holding	Percentage of owners	Percentage of land
From 0 to 1 acre	20·2	0·8
From 1 to 3 acres	28·6	5·2
From 3 to 5 acres	14·9	6·2
From 5 to 10 acres	16·9	13·1
From 10 to 15 acres	7·3	9·1
From 15 to 20 acres	3·6	7·2
From 20 to 25 acres	2·2	5·6
From 25 to 50 acres	3·9	14·8
From 50 acres and over	2·4	38·0
TOTAL ..	100·0	100·0

It shows that the size of holding in case of small owners has further decreased while the holdings of big owners have increased. As pointed out earlier, only one person out of eight in the province owns any land at all, though over 80 per cent are dependent on agriculture. The study by the Economic Board in 1939 is somewhat disquieting as it shows a definite increase in the area owned by owners of over 50 acres at the expense of almost every other class of owner. The fact that income-tax is not levied on agricultural income may be a major cause of this tendency. This requires further study, as it may be an unhealthy tendency.

The holdings less than one acre in area deserve special mention. A large number of these may be mere allotments owned by labourers or petty grants made for a religious purpose but the inquiries definitely revealed that fully half the owners of these plots were agriculturists. It would, therefore, be interesting to know how these plots are cultivated, what is the economic position of their petty owners and what other source of income they have got. The number of such holdings is very large in five districts : Rawalpindi 32 per cent, Kangra 31.8 per cent, Simla 30.7 per cent, Muzaffargarh 30.4 per cent and Dera Ghazi Khan 30.2 per cent.

Cultivators' holdings.

Here the ownership and tenancy are ignored and the whole area cultivated by the cultivator whether as owner or tenant is taken into consideration. This inquiry was also conducted by Mr. Calvert and results were published in 1928. The table below gives the detailed figures :—

Size	Cultivators.		Per cent. of cultivated area
	Number	Per cent	
1 acre or less	904,000	22·5	1·5
1—5 acres	1,332,000	33·3	12·1
5—10 acres	848,000	20·5	20·6
10—15 acres	410,000	10·2	17·4
15—20 acres	212,000	5·3	12·3
20—25 acres	128,000	3·1	9·1
25—50 acres	164,000	4·2	18·5
Above 50 acres	20,000	0·9	7·9
Total	4,018,000	100·0	99·4

The average area cultivated by a cultivator is about 7.2 acres and the total number of cultivators according to this inquiry is 4,031,137, *i.e.*, about 14 per cent higher than the owners. The difference is due to the fact that the number of landless tenants is larger than the non-cultivating owners. It will be seen that 904,000, *i.e.*, 22.5 per cent of the cultivators cultivate one acre or less though this land is only 1.5 per cent of the whole and 33.3 per cent cultivate 1—5 acres and the land is 12.1 per cent. About 50 per cent of the land is cultivated in holdings of from 5—20 acres by about 36 per cent of the cultivators. Combining the first two groups the following districts show over 50 per cent of their cultivators cultivating 2½ acres or less : Simla 90.8, Kangra 80.4, Hoshiarpur 74.5, Rawalpindi 64.4, Jullundur 56.2 and Sialkot 55.6. How such a large number of these small plots are cultivated requires further study.—

Size of holding per plough.

So far we have discussed the size of owners' holding and cultivator's holding but the size of holding controlled by a pair of oxen, usually called "one plough", is quite different. For the Punjab, as a whole, a pair of bullocks controls about 14 acres, though there are considerable variations from place to place according to the size and quality of bullocks and local agricultural conditions. Under canal irrigation, as in Lyallpur, there are 14 acres to a pair, in Jullundur and Hoshiarpur, where wells are to be worked for lifting water, there are only 8 acres to a plough, Kangra has got 4½ acres and Simla only 3 acres to a plough. This is probably due to small size and poor quality of bullocks, small holdings and also because some extra animals are kept as reserve. Rohtak has got 22 acres and Attock 27 acres.

Land Tenure.

Another effect of this unequal ownership of the land is that it leads to tenant farming. Taking 10 acres to be the size of the holding managed by one pair of bullocks, it will be seen that 80.6 per cent of the owners own less than 10 acres. In order to make it into an economic holding this class of owners feel the necessity to take some more land into their holding if it is available or give their land to neighbours and themselves work purely as tenants on bigger holdings.

It is for this reason that about 50 per cent. of the area is cultivated by tenants at will. The table below gives the percentage of total cultivated land held by tenants paying rent in some districts—

District		Proportion of total cultivated land held by tenants paying rent.
Kangra	..	35·4
Rawalpindi	..	38·8
Ambala	..	43·0
Hoshiarpur	..	53·3
Jullundur	..	44·9
Ludhiana	..	42·4
Ferozepur	..	53·9
Lahore	..	55·7
Amritsar	..	52·6
Montgomery	..	79·3
Multan	..	74·4

The first six districts showing lower proportion of land cultivated by tenants have got larger proportion of land held by small owners, while Montgomery and Multan Districts with high proportion of land cultivated by tenants have got a larger number of big owners.

The usual practice is to divide the gross produce into half and half between the landlord and the tenants, but in case of good land often a higher share is, by agreement taken by the landlord. The tenant has practically no security of tenure beyond his claim to harvest the crops he has sown, though no landlord will eject a satisfactory tenant, since he is hard to replace. Legally he can be ejected by serving a notice to this effect before the 15th November preceding. He has no claim to the residual value of manure. The only claim recognised by law is to the value of uncut crop sown by him and the cost of preparation of land which he is not able to sow due to ejectment. He is also entitled to compensation for disturbance in certain circumstances and for improvements made by him. In the interest of agricultural improvement our objective should be greater security of tenure for tenants with compensation for displacement which may be equal to at least one year's rent. In addition, permanent improvements such as sinking of wells, planting of trees and gardens should be paid for in full. The landlord would have to be notified before such improvements are undertaken. Another reform that is needed is to make it necessary to register tenancy agreements fixing the share of landlord and tenant. Once fixed, such division should not be liable to frequent changes.

Remedies for over population.

Smaller family is of course the first and the most direct remedy. The recent discovery of methods for release of atomic energy opens up new possibilities even as regards food production and this may lead us to modify our views regarding the urgency of limitation of families.

Emigration.

Comparatively little is possible except in settling new irrigated areas and even for that the outlook is not too promising. Reclamation of vast areas of eroded land locally known as *darrar* in submontane district is another possibility.

Industrialisation.

This is very necessary in the Punjab to balance Agriculture and enable some of the rural people to earn both from agriculture and industry. We should in the Punjab spread our industries as far as possible, with this object in view. Such industries as oil-pressing, rice-hulling, vegetable ghee manufacture, cotton-spinning and weaving, wool-weaving, tanning, etc., are instances which offer scope for expansion.

Subsidiary occupations.

In the canal colonies an average farmer is working 166 days a year only. In well-irrigated-cum-*barani* tracts, the working days are 230. The corresponding figures for bullocks are 112 and 160 respectively. There is, therefore, a big surplus of partially idle labour. The subsidiary industries suggested are silk-worm rearing, embroidery, lace-making, spinning, toy-making, poultry keeping, bee-keeping, dairying, sheep-keeping, fruit and vegetable-growing and canning. (See Chapter XX).

This has been dealt with elsewhere in this book. One of our big needs is improvement in marketing and storage facilities. Some steps are being taken regarding these matters and especially in making market practices and weights uniform and in reducing the number of trade allowances or deductions under the Marketing Act. Constant progress should be aimed at along these lines.

Improvement of agriculture.

Increase in production.

For many years before the War India was an importer of foodgrains ; 1½ million tons of rice used to be imported annually from Burma, Siam etc. There is also very great demand for foodgrains in Japan and Europe. Further, there will be increased demand for other crops, like cotton and oilseeds, owing to greater need for consumption goods. This all-round demand can be met only by increasing production in all directions. There are various means for increasing production but the following three are important :—

1. Irrigation.

It is well known that yields on irrigated lands are certain and higher but at present only 25 per cent. of the cultivated area is irrigated in India. The remaining 75 per cent. has to depend on rainfall which may be sufficient in quantity in some parts but may not be timely. There are vast areas where it is insufficient and erratic. Artificial irrigation is, therefore, necessary to insure production. Every effort should, therefore, be made to develop canal irrigation and well irrigation, wherever possible. In the remaining area dry farming methods should be followed to make the best use of the available moisture.

2. Better cultivation.

It is admitted that our indigenous implements are very inefficient and their output is very small. There is, thus, an urgent need for improving them. Improved implements, such as furrow turning ploughs, chaff cutters, automatic drills, hoes and harrows have been introduced to a certain extent but, much more remains to be done both in making more widespread use of the above implements and by improving others. Cheap and efficient water lifts, threshers and carts are an urgent necessity.

3. Use of artificial manures.

The most spectacular improvement made in the West by the application of science to agriculture is the use of artificial manures. In India at present very small quantities are used. The Punjab hardly uses 1,000 tons of ammonium sulphate per annum and practically nothing of phosphate, potash and lime. There is, thus, a great scope for their extensive use. These artificials are at present all imported and their price is consequently high. The Fertiliser Commission recommended the establishment of one factory at Sindri near Dhanbad for the manufacture of ammonium sulphate. It is hoped it will start working shortly. There is need for one in the Punjab as gypsum a major ingredient in the manufacture of ammonium sulphate is available here in large quantities.

Improved seeds are also helpful in increasing yield to a certain extent but better cultivation and manuring are necessary to maintain high yields of better varieties.

Forests and arboriculture.

The timber and fuel resources of the province are managed by the Forest Department controlled by a Chief Conservator and a number of assistants. The pre-war expenditure of the department was approximately 27 *lakhs* and their receipts about 23 *lakhs* of rupees. Reclamation and prevention of erosion is carried out by a special officer. Excellent work has been done by the department in the past in the face of many difficulties and some unpopularity. Its general organization, however, will need to be kept intact, but possibly on a different basis. Our capital in the form of timber has been sadly depleted during the war and heavy expenditure on renovation and replanting will now be necessary. A provincial policy needs to be worked out to deal with (*a*) hill forests (*b*) reclamation and prevention of erosion (*c*) Working out a sound programme for the plains—both in *barani* and irrigated tracts.

As regards (*a*) above no suggestions are offered but presumably the department's proposals for post-war development will receive serious consideration. We deal below with (*b*) and (*c*).

Soil-erosion. This means the removal of the surface soil thereby making good fertile soil barren and un-culturable. Erosion may be caused by wind or water.

Wind-borne erosion occurs in the desert tract of South-east Punjab and Thal tract in Mianwali District. The movement of wind blown sand can be controlled by planting wind breaks and shelter belts in the desert fringe districts of Gurgaon, Hissar and Mianwali.

The erosion caused by fast-flowing water in higher hills is more dangerous and the damage done to the Punjab soils is enormous. The fast flowing water washes away the top fertile soil in high hills and th s makes them poor. Further, the coarse sand thus washed away is often deposited on top of good soil in the sub-montane area by *chos* in Hoshiarpur District. Another kind of damage done on steep soils is by sheet erosion due to heavy rain. This results in poor soil—badly cut up by deep ravines—locally known as *darrar* lands. The erosion in high hills and foothills is due largely to indiscriminate cutting down of trees and uncontrolled grazing which results in fast flowing rain water coming down the hills. This can, therefore, be checked by strictly controlled felling of trees and of grazing in higher hills. In the submontane area gully plugging and building of small dams and the plantation of shrubs and trees has been found to be of great help. The prevention of erosion will thus not only conserve fertile land but will also save valuable water which will be available for irrigation. The work so far done by the Co-operative and Forest Departments has shown that very large blocks of *darrar* lands can be saved by terracing and contour bunding under proper guidance and co-ordination of work. This can now be done more easily and quickly as heavy earth-moving equipment, consisting of bull-dozers, terracers, subsoilers, etc., will be available from the army as surplus war material. Under the Post-war Development Scheme it is proposed to reclaim 150,000 acres of now useless *darrar* land and to increase the productivity of 350,000 acres of poor and unterraced land already threatened with erosion. This will also provide employment to demobilized soldiers, as a lot of manual labour will be needed to complete this work. Fortunately, most of the land to be thus reclaimed lies in those districts which have supplied the largest number of recruits to the army—Attock., Rawalpindi, Jhelum, Gujrat, Hoshiarpur and Ambala.

Another line of work is the reclamation and improvement of waste lands, so as to make them more productive for timber, firewood, fodder grass, thatching grass, resin and gum extraction. There is plenty of such land along the bed of every torrent, small stream and large rivers throughout the Province, particularly below Hoshiarpur and Ambala Siwaliks. With controlled grazing and energetic planting programme they are capable of producing abundant timber and firewood. Similarly Thur and water-logged areas can be reclaimed for tree planting.

The work in the foot hills is a matter of vital interest for the province as a whole as it tends to preserve river supplies, by regulating sub-soil absorption, avoiding disastrous floods and tending to raise sub-soil water in districts, such as Jullundur, where it is now getting lower year by year. The province as a whole, therefore, should subsidize this work and thus relieve local interests from having to bear the greater part of the burden.

Plains policy.

The spread of canal irrigation has caused large areas of waste land producing a certain amount of fuel and managed by the department, to disappear. Some irrigated plantations have been started, to partly redress the balance. The most important of these are at Pirowala (19,281 acres,) probably the largest irrigated forest in the world and at Chichawatni (11,494 acres) and Chhangamanga (10,845 acres) on the Lower Bari Doab Canal and Arifwala (1,519 acres) on the Sutlej Valley Project. The great shortage of fuel during the war has demonstrated the inadequacy of our present fuel resources. The spread of cultivation in Sind and Bahawalpur will, in future further reduce our imports both of fuel and charcoal. It is imperative, therefore, that steps be taken to increase our fuel resources.

Irrigated plantations.

In spite of what has been stated above it must be admitted that these irrigated plantations give a monetary return to the country of probably less than half of what could be obtained by cultivation of crops.

Again, though these forest plantations received water in summer only—April 1st to October 1st—one would have expected them to be started as far as possible at the heads of canals, so as to avoid distant carrying of a seasonal supply. The Pirowala Forest is 130 miles from the head of the L. B. D. C. and is possibly the worst case of wrong siting.

Arboriculture.

It is probably in systematic arboriculture that a province-wide effort is most needed. Individual trees scattered over cultivated areas are a very expensive luxury as they cause much damage to crops through excessive shade and roots interfering with cultivation. On the B.C.G.A. farm at Khanewal an effort has been made to keep a right balance by having a plantation of ¼ acre in the centre of every hundred acres and 73 such plantations exist on the farm. It is in the villages in the plains, particularly in irrigated tracts, that most room for tree planting exists. A very determined and consistent policy is essential if trees are to be grown and protected from livestock in their early years, in the villages. The Kashmir Government has tried to solve this difficulty by creating an 'Arboriculture day' throughout the state and a fair amount of success has been achieved. There is, certainly, evidence everywhere of definite efforts being made. The Forest Department in the Punjab could assist by giving free, small saplings of *kikar* and *Shisham* at convenient centres. Trees in our village sites do not interfere with crops, give shade to men and beasts and serve partly as fuel reserves, thus saving manure having to be converted to dung cakes. A survey of possibilities in this direction would clear the deck for further action.

Village amenities.

Pioneer work has been done in this direction by Mr. F. L. Brayne in his village uplift work. Careful study and planning would avoid much of wasted effort in early 'uplift work'. Discouragement only will ensue if too rapid a change is pressed on the villages. Villages should be planned with wide central roads copiously planted with trees. The well should be near the centre of the village and arranged so that water raised by either a persian-wheel or a pump should be passed on to a closed tank from which various communities can have separate taps. Places of worship and the village post office and the school should be situated as near the centre as possible and an open place left for social or other gatherings. There should be an enclosure and a house allotted for each *square held* by a *tenant*.

A *pucca* brick washing platform should be arranged—either on the irrigation channel or attached to the well tank. The use of cement for this and similar structures should be encouraged. Villagers ought to be encouraged to burn their own bricks.

Village pond.

At least once in ten years fish should be introduced into village tanks. They help to keep down mosquitoes and add to the variety in diet. It would be interesting to note that recent work done in U.S.A. shows that a one-acre pond produces more animal proteins through fish than can be produced through any other animal crop.

Manure and human excreta.

An effort should be made to provide shelters and encourage the habit of defecating in the fields—or over manure pits, so that as in China, no waste takes place.

School.

This should be encouraged to become the centre of social life in the village. Books and pamphlets on rural reconstruction should be available with the school master, who ought to be the natural leader in ameliorating village life. To get all this going it is desirable to have a central department for rural reconstruction. This need not be expensive and top-heavy. The head of it should preferably be an agricultural graduate who has studied village life in China and Europe.

Village factions.

Litigation caused by village factions is very rife in the Punjab and wastes the cultivator's substance and time. A simple difference of opinion can often be fanned into a serious quarrel—often encouraged by interested parties or petty officials. This tends to keep educated officials from settling in villages and thus deprives the villages, of informed leadership. One of the great needs of our villages is good leadership. The village lambardars and zaildars, as they derive their position largely by inheritance are often unsuitable as leaders—being more dependent on government than on the people. Under such conditions corruption and bribery flourish.

Panchayats.

With a view to reducing litigation and fostering rural reconstruction, panchayats have recently been started. In 1944 they numbered 7,000 and are expected utlimately to number 20,600. The present staff consists of 37 Panchayat Officers and 121 Assistants, later to be increased 300 per cent. A large number of village and other supervisory staff will also be needed. The usefulness of these panchayats would possibly be enhanced if they held their position really by election.

Co-operation.

The Punjab has Primary Co-operative Societies, Central Co-operative Banks and one Provincial Co-operative Union. Though great work has been done in the past in bringing cheap credit to the cultivators, there is still an enormous field open for further development. We need co-operation in all village activities, in buying, selling, purchase of the more expensive implements, road-making, tree-planting, well-sinking and innumerable other directions. If this spirit could be developed further it may be possible to start collective farming and other organized developments, which would raise the general standard of village life.

Miscellaneous industries.

In addition to weaving, leather work, oil seed pressing, flour-milling of maize, wheat, gram, etc., which could be introduced in almost every large village, there is room also for developing silk culture (in sub-montane and some plains districts) and bee-culture (for honey production) in favourable areas.

With the development of hydro-electirc power the whole Eastern Punjab will, before long, be able to instal small motors which could be used for (*a*) flour-milling (*b*) water-pumping and (*c*) chaff-cutting. In the Western Punjab small crude oil engines ought to become popular after the war and they can be used in the same way as electric power.

Mushroom growing.

Another Industry that has never been developed in India is mushroom-growing. There are edible mushrooms indigenous to the Punjab and Bahawalpur. These have never been studied by the Agricultural Department as yet. Mushroom, as served in European hotels, costs over Rs. 5 a pound and are all imported. Field and jungle mushrooms are common in Kashmir and since the war are being exported in considerable quantity as dried mushrooms to the plains. Mushroom can be cultivated artificially, and spawn can now be had from the Agricultural Department in Madras and shortly from Lyallpur. Successful rearing of rice-straw mushrooms from Coimbatore spawn were made at Khanewal this autnmn. Much work requires to be done in this line.

New crops.

There is room in India for many new crops. Here in the Punjab the most obvious new crops required are the following :—

(*a*) A rapidly-maturing *zaid rabi* crop which could be sown in the middle of March and would get its last watering in middle of May in canal irrigated tracts in Western Punjab. Experiments at Lyallpur have shown that wheat does not require irrigation after 7th or 10th March and cotton-sowing is now done after 15th May—especially American cotton. Except for small areas of cane and early green manure crops there is no demand for water at that time. The canal can run full as a rule after early March, so there is a big gap here not yet fully exploited. Canal authorities claim there is no demand for water on account of harvesting in April and often adopt a month or longer closures for annual repairs at this period. As the canals are in any case run in rotation from October to February there is plenty of time usually for repairs during the winter season and no closure is essential in April-May.

(b) A leguminous oilseed, such as the soya bean to partly replace wheat or toria. Though soya bean is normally a summer crop there are varieties suitable for winter growth. We have too much wheat in the Punjab, and it exhausts the soil, whereas, soya bean would add nitrogen to it and improve our weak oilseed position. The soya bean is the basis of the agriculture of North China, Manchuria, etc., and has in recent years spread largely in the U.S.A.

(c) A fibre crop in *kharif* as a substitute for cotton and an insurance against low cotton prices. At present no suitable fibre crop is available in the province.

Power farming.

If suitable tractors become available after the war there may be room for much development in power farming. One big result of using mechanical power would be reduction of the fodder area —which amounts to 15 per cent of the cropped area, a good portion of which is required for working bullocks.

Problems connected with consolidation and amalgamation of holdings to secure a larger economic unit of land would also arise.

Some of the advantages of large scale farming are summarized in a publication by one of us. Much saving of water is possible by large-scale farming in the canal colonies.

Collective farms.

To clear the ground for further progress in agriculture it may be necessary in future for government to take power to do the following :—

Legislation.

(*a*) A law to prevent division of land below a certain fixed minimum area—possibly 12 or 14 acres in perennial canal areas and about 20 or 25 acres in some *barani* tracts, *e g.*, Ambala, Hissar, etc., and 8 or 10 in others, such as, Jullundur, Gurdaspur.

(*b*) To facilitate consolidation, power should be given to government to make this compulsory on the advice of a non-official district committee backed by provincial board.

(*c*) The right must be taken by the state to expropriate both a tenant or a landlord, who will not cultivate or develop his holding efficiently. Safeguards must be devised to avoid tyranny and unfairness or political animosities affecting the issue.

(*d*) Right of the state to amalgamate areas and compel collective farming in the national interest.

(*e*) Efforts so far made by the Agricultural Department to control abnoxious weeds, insect pests and diseases and wild animals have not proved very fruitful. Legislation seems to be the only remedy.

The most common unit of farming is a 'one plough holding' cultivating about 6 acres in case of well irrigation, 12 to 14 acres in canal areas and 25 acres or so in *barani* areas. The individual cultivation of such small holdings is considered defective in more than one way. In the first place it is very difficult to introduce improved seeds due to a number of crops being grown on small areas. Secondly it is not possible to use labour-saving implements such as furrow turning ploughs, horse

Large scale farming

hoes, etc. Thirdly, there is great waste of water which is very precious in the Punjab. Further, no systematic plan for growing trees for timber or fire wood can be practised. In order to remove all these drawbacks it has been suggested that large-scale farming is essential for effecting any substantial improvement.

Large-scale farming can be of two types—in one case the land is cultivated by tenants on the usual share system, locally known as *batai* but the managing agency controlling large area, is in a better position to bring about improvements. Most of the big estates in Western districts of Shahpur, Multan and Dera Ghazi Khan are cultivated under this system. Some of the big seed farms, where land has been granted by the Government on certain terms, are also cultivated on these lines. The advantages of a large-scale control, as achieved on the B.C.G.A. Estate at Khanewal, are mentioned below.

(*a*) At the centre of every 4 squares or 100 acres a small plantation of ¼ acre is planted under trees. Tenants are encouraged to keep their cattle in these enclosures and thus ensure most of the manure returning to the land. Trees scattered over fields cause much damage to crops and are uneconomical and wasteful if so grown. The villages which cater for two chaks or say 2,000 acres can also be organized more cheaply for arboriculture if control is in the hands of one authority.

(*b*) Good selected seed can be provided more easily for large areas than for scattered holdings.

(*c*) Good land will produce double the yield of poor land with same expenditure of water and by having control of large areas it is possible often to avoid wasting water on poorer portions of an area. This cannot be rigidly applied for reasons connected with rotation plan. By adopting uniform crop rotation the water channels can be kept running in the crop only and not over uncultivated or fallow areas.

(*d*) A consistent policy for green manuring can be more easily followed in large estates than in small ones.

(e) Cultivation and interculture can be levelled up to a high standard by adopting a uniform policy, and by encouraging all to work according to plan.

(f) Implements which the one square or even two square man cannot afford can be easily supplied on share basis of expenses acceptable to tenant, e.g., reapers, threshers, etc.

(g) Repair and upkeep of implements is much more satisfactory when arranged on a large scale. It is also much easier to secure essential items such as steel, cloth and other necessities.

(h) Harassing by petty officials can be largely obliterated. Care, of course, has to be taken that one's own employees do not take their place as extortioners. A further big advantage is keeping the police out of the area and settling disputes by panchayats in which the lambardars or headmen take a prominent part. The chief defect of the system is that the tenant does not benefit to the extent he should as the landlord gets his share of all increases. The reduction of fodder prices is one way in which a good tenant is encouraged, though here again some abuses may creep in and a careful watch has to be kept that favouritism and corruption are eliminated. There is no doubt, however, that the total production of a large area controlled by one authority is far higher than the sum-total of small individual and unorganized holdings.

Power farming

Another type of large-scale farming is where cultivation is done by tractors in place of bullocks. It is admitted, small-scale farming by bullocks gives generally a small return to the cultivator and is comparatively expensive and may in some cases not be able to compete with produce raised by mechanized methods elsewhere. In the Punjab on basis of 12 acres per plough, there is a surplus of workers of 343,000 representing a population of 2 million or 8 per cent. of the total population.* For British India, as a whole, the figures are still more disquieting, viz., 15½ million surplus representing a population

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**Poverty and Social Change*, by Tarlok Singh.

of 71½ million or 28 per cent. of the population. Mechaniz agriculture may accentuate this surplus, but it must remembered that a portion of the displaced persons wou find employment in industry. The ultimate objective migl be 60 per cent. agriculture, 25 per cent. industry and 1 per cent. services. If mechanized farming results in great production of food and other commodities at less cost to tl community, it must make headway, particularly in can areas. The great saving in eliminating most of the 15 p cent. area now devoted to fodders, is a big factor in tl situation.

Lessons from China.

Both the authors have had experience of China an one of them visited Schezwan in April an May, 1944 only. Chief points of interest t India we wish to note are—

1. Only a third of the draught animal population o India is used in China and their number per unit of area i only about one-half. The other one-half of the work i done by manual labour. In Japan also a similar state o affairs exists. On the other hand a very large population o smaller animals, such as pigs poultry, ducks and fish whicl mostly live on by-products, but produce a large quantity of food for man, are kept. This arangement has been forcec on China due largely to pressure of population, the aver age area per person being less than half of what it is in India.

2. All the oilseed, including tung and soyabean, are crushed in the country and surplus oil is exported, but no oilcake is sent out of the country. Most of it is used as manure.

3. The use of manure, particularly human excreta, is very highly developed. It is reckoned that one-third of the holding (about 6 acres) is manured yearly from excreta of the family.

4. Soyabean is a very popular crop. It is both an oilseed and a pulse. It is a rich food and has many uses in China. It has also spread in America and now occupies over 9 million acres. Practically none was grown in U.S.A. in 1920.

5. Tung tree. On the slopes of hills, which cannot be otherwise used profitably, tung trees are grown.

6. The country system of organisation for rural developments is very instructive. The use of well-organised *bagar* or compulsory labour for road-making and community purposes is worth emulating in India.

As the problems in India and China are more or less of the same type it is suggested that India might send at least a dozen students to China yearly to study rural development and agriculture, particularly, manurial practices, as there is much to learn from there.

References.

1. Size and Distribution of Agricultural Holdings in the Punjab, by H. Calvert (Board of Economic Inquiry Publication, No. 4).

2. Size and Distribution of Cultivators' Holdings in the Punjab, by H. Calvert (Board of Economic Inquiry Publication, No. 11).

3. Proprietary Holdings in the Punjab—Their Size and Distribution, (Summary).

4. Population and Agriculture, with special reference to Agricultural Over-Population. (League of Nations Document, No. 1.).

5. Indian Rural Problems, by Sir Mani Lal Nanawati and Anjaria.

6. Poverty and Social Change by S. Tirlok Singh, I.C.S.

7. Reports of the Forest Department.

8. Estate Farming in India, III (British Cotton-Growing Association, Khanewal), by Sir William Roberts.

Indian Farming, Vol. III, No. 4. April, 1942.

9. Excerpts from the Address by Mr. Harry Ferguson at the International Food Conference, June 1943.

country. It is, also, sometimes used as a preservative for fruits.

In the Punjab honey is produced as a wild, as well as, home product. The most important areas of production are Kangra District, especially Kulu Sub-Division, Dalhousie area of the Pathankot Tehsil, Simla District, Una Tehsil of the Hoshiarpur District, and Murree Tehsil of the Rawalpindi District. It is estimated that the total productiou of the *jungle* or wild honey is about $5\frac{3}{4}$ thousand *maunds* and that of the domestic honey about $1\frac{1}{4}$ thousand *maunds*. The total production is in the neighbourhood of 7 thousand *maunds*. Apart from this about 2,500 *maunds* are imported from the adjoining hill states and N.-W.F.P., the most important being the Kangra and Simla Hill States and Jammu aud Kashmir States, which account for nearly three-fourth of the total imports. Thus, the total available supply for consumption in this province is about 9,500 *maunds*.

While these are the figures of total available supply of honey in this province, the quantities marketed are much less than this. It has been estimated that nearly 60 per cent of the honey produced in this province is consumed by the producers themselves and the total supplies, including imports, handled in the organized trade channels is about 5 thousand *maunds*. Most important assembling markets are Kulu Sultanpur, Dharamsala, Kangra Nagrota, Simla and Murree, while the distributing markets are Amritsar, Lahore, Rawalpindi, Hoshiarpur, Multan, Jullundur, Sialkot, Ludhiana, Ambala, and Jhelum, mentioned in the order of importance. Two varieties of honey are recognized by the trade—(*a*) white, and (*b*) amber or dark-brown. White honey, which is chiefly obtained from Kulu (autumn crop), Chamba and Kashmir States fetches a higher price than the coloured honey which is obtained from the spring crop of Kangra Valley, sub-montane districts and the Punjab plains. The other factors which affect the price of honey are the method of extraction and cleanliness, consistency or stage of ripeness, freedom from adulteration, taste, flavour and aroma.

Honey obtained by squeezing method often contains impurities like wax, pollen, carcases and juice of crushed bees, dust, dried leaves, etc. Extracted honey is generally free from these impurities. Thick consistency is considered to be better as thin honey is liable to fermentation. Wild bees usually yield honey of thin consistency and poor keeping quality. It, therefore, sells at a discount. Similarly, honey liable to granulation is considered as an inferior product by the trade, but in hilly areas and among some consumers this is not considered as a disadvantage. The chief adulterants used are sugar, syrups, and moaasses. The adulteration is mostly done in the plains. The flavour of the honey depends upon the flora system from which the bees gather the nectar. Honey produced by bees fed on clovers and soapnut trees is generally mild-flavoured, while honey gathered from shisham, barberry and buckwheat is generally strong flavoured.

Introduction and improvement of domestic bee-keeping.

Though the culture of bees in indigenous hives in the Punjab is as old as history, yet the initiating of modern domestic bee-keeping dates back to only eighties of the last century, when (Sir) Louis Dane kept bees in Kulu in movable frame hives. It was he who as Lieut. Governor of the Punjab aroused interest in the industry in 1908 and himself experimented with swarms of bees. Since then many attempts were made to take to bee-keeping on modern lines but they all resulted in failure and much progress was not made till a Punjab Government research scholar returned from U.S.A. after receiving training in agriculture and started work first at Raison and then at Katrain in 1939. Research work on bee-culture in the province has proved that besides hills, bees can be kept even in the Punjab plains. At Nagrota, in favourable years, a yield of 56 lbs. from a colony has been obtained. Similarly, in Katrain Farm, the maximum yield attained has been 97 lbs. and that from Lyallpur Farm 60 lbs. 2 ozs.

Kinds of bees.

There are three kinds of bees in the Punjab :—

1. The Giant honey-bee (*Dumna* or *Bhandaur*—

Apis dorsata F.) It is found in the lower hills and sub-montane districts. It builds a single large comb, generally on tall trees, which may yield as much as 80 lbs. of honey in a year. It has a ferocious temperament and is prone to migrate and is, therefore, unsuitable for modern hives.

2. The little honey-bee (*Chhoti Makhi*: Apis florea F.) This is common in the Punjab plains. It builds a single small comb among bushes and hedges which gives 1 to 2 lbs. of honey in a year. It does not live in captivity and, therefore, it cannot be kept in modern hives.

3. The Indian honey-bee (*Darohla* or *Mahun*: Apis indica F.) It is usually found in hilly tracts of the Punjab. It builds parallel combs in the cavities of tree trunks. Under domestication it is kept in special "wall-recesses". A single colony yields on an average 8 lbs. of honey in a year. It is best adapted for modern bee-hives and responds well to better management.

A bee colony consists of a queen, workers, and drones.

Bee colony.

There is usually only one queen in a colony. She has a well-developed sting which is used to kill other queens. She lives on an average for 2 to 3 years, and her function is to lay eggs which may be as many as 1,500 per day in the active season. The eggs are of 2 kinds—(*a*) fertilized eggs which produce workers or queens, and (*b*) unfertilized eggs which produce only drones (males). She leaves the colony only for mating or when swarming. The young one destined to become a queen is reared in a special cell and is fed on a richer and more nourishing food called "Royal Jelly", specially manufactured for her by the workers.

Each colony has a number of drones. They have no sting and are usually fed by workers. Their only duty is to mate with the queens. Their normal life is about 2 months but are usually killed before monsoon and winter.

The workers are imperfectly developed females which usually do not lay eggs, and may be as many as 20,000 or more in a colony and form the main strength of the colony. They do all the work pertaining to the well-being of the colony. Normally they live for 6 weeks, but in winter they may live as long as 6 months.

The nest is built in the form of a series of parallel combs in the cells of which the brood is reared and pollen and honey stored. The filled cells are provided with a cap —worker brood cells have flat capping, drone brood cells have bulged capping with a hole in the centre and honey cells have flat air-tight cappings.

The queen begins to lay eggs with the advent of spring. The egg stage lasts only for 3 days, larval stage for about 6 days, and pupal stage 7½ days in case of queen, and 12 and 14½ days for workers and drones respectively. When the new queen is ready to emerge, the old queen along with a large majority of workers, who have filled themselves with honey, leaves the nest on a warm day to start a new colony. The whole swarm moves within 2 to 48 hours. After swarming fever is over, the bees in the 'parent colony' settle down to their work of gathering nectar and pollen from flowers.

During April and May, there is a honey-flow in several localities in the Punjab. The colonies should be strong just before that. At the end of flow, honey should be extracted leaving 15 lbs. of honey per hive for the bees to pass the summer. During summer and monsoon there is no honey-flow. The queen lays fewer eggs. Enemies of the bees such as wasps and wax-moths become active and weather conditions are unfavourable. If there is not enough honey in the hive, bees should be fed on sugar and each colony should get enough of it to make up 15 lbs. of store. They should also be protected from heat, rain, ants and enemies, otherwise the bees may abscond.

In some localities such as Kulu Valley and Lyallpur, there is a second honey-flow during September-October.

In the winter season colonies should be protected in hills by packing. Only strong colonies with plenty of honey stores (20 to 25 lbs.) and a good queen should be allowed to winter over. Weak colonies should be united with strong ones.

Honey extraction.

When honey-flow has stopped and more than ½ to ¾ of the honey cells have been capped they should be taken out and cleaned of the bees with smoke and green grass. Uncap the combs with a hot uncapping knife, put two uncapped frames in the extractor and revolve it first slowly and then briskly. Honey will be thrown out. Reverse the frames and revolve again. The honey should then be allowed to settle down for 3 to 5 days before bottling it. The wet combs should be given back to the bees for removing the residual honey.

Plants.

The important plants which provide nectar and pollen for the production of honey in the hills are—

(a) Plants supplying nectar: *shain* (Pleatranthus rugosus): polygonum. sp. : strobilanthes sp. ; *bhres* (fagopyrun sp.); *sarson* (brassica sp.); *kasmal* (berberis sp.); *tun* (Cadrela toona); soapnut (Sapindus detergens); *shisham* (Dalbergia sisoo); *puna* (Ehretia acuminata); *jaman* (Eugenia sp.); plums; pears; apricots; apples; *kainth* (pyrus sp.); and citrus.

(b) Plants supplying pollen: maize; *sarson*, wild pomegranate; *isapgol* (Plantago sp.); *kasmal* (Berberis sp.); citrus; and wild rose.

In the plains the important plants are almost all fruit trees, vegetables, specially cucurbitaceae, oilseeds, like toria and sarson and leguminous fodders, like lucern, *berseem*, *senji*, etc.

Enemies.

The natural enemies of the bees are: The wax-moth, wasps, black ants, and bee-eater bird (*sone-chiri*).

The caterpillars of the wax-moth feed upon the bees-wax by making silken tunnels in the combs. To control the pest the silken tunnels and caterpillars should be removed as often as possible from the combs during monsoon and fumigate the combs in store with carbon bisulphide or sulphur fumes.

The wasp can be killed with fly-flapper at the entrance or by fumigating their nests with calcium cyanide.

The black ants take away honey, brood and pollen. They fight with bees and when infestation is high the bees abscond. They can be controlled by placing the bee-hives on wooden stands with their legs in earthen cups containing water. Destroy ant nests in and around the apiary by pouring in a solution of potassium cyanide (highly poisonous to human beings also) prepared by dissolving 1 oz. of potassium cyanide in 4 gallons of water. After pouring in the solution the entrance should be closed with mud.

Bee-eater (*sone-chiri*) is a migratory bird which arrives in the Punjab (Lyallpur) towards the end of February and leaves in October. It should be controlled by shooting.

How to start.

It is suggested that one should make a start with 1 to 5 colonies and the number can be increased gradually with experience. The hive should be located in a place which has plenty of wild and cultivated nectar plants within a radius of 1 to 2 miles. It should be protected from wind and should have a good water supply. The hive should be placed 6" to 9" above ground and its back should be one inch higher than the front. It should face eastward and the distance between the two hives should be 6 feet and the ground round about free of weeds.

The cost of the total equipment for starting one colony is about Rs. 22 and for 5 colonies it comes to about Rs. 94. The comb foundation is available with the Entomologist, Punjab Agricultural College, Lyallpur at the sale rate of Rs. 3-15-0 per lb. or As. 9 per sheet. The charges for converting bees-wax into comb foundation are As. 13 per lb. with an additional requirement of 15 per cent more bees-wax than the weight of the comb foundation supplied in return.

The beginners in bee-keeping are advised to get prectical training at one of th 3 Government Farms—

The total quantity required is about 230 *maunds*, which can be obtained from 25 full-grown mulberry trees. Leaves should be collected twice a day—in the morning at about 10 and in the evening before sunset. The leaves collected in the morning are used for mid-day and the evening meal and those collected in the evening for night and the morning meals. Upto second stage an extra meal may be given, while in the last stage only 3 meals are sufficient. Each time the worms moult the meals should be small and frequent. No food should be given in the moulting stage to avoid disturbance. It is essential that the refuse leaves and the excreta are removed and racks kept clean during each stage.

Till recently silkworm-rearing was confined to 4 districts of Gurdaspur, Hoshiarpur, Kangra and Rawalpindi and seed used to be imported from France and Italy. In 1939-40 the production of disease free seed on scientific lines was taken up at Palampur. As the demand for seed increased owing to expansion of silk-rearing to 16 districts a second 'grainage' was established at Dalhousie in 1942-43. The table below shows the quantity of seed produced, number of rearers and the number of villages where rearing is done :—

Year	Quantity of seed produced	No. of rearers	No. of villages
1941-42 ..	1,554 ozs.	1,042	365
1942-43 ..	1,959 ozs.	1,297	354
1943-44 ..	2,313 ozs.	1,941	469

Reeling.

The rearers have now begun to reel the cocoon themselves before selling as they find it remunerative. 150 domestic reeling plants are at present working in the rural areas where silk worms are reared.

Outturn.

In the case of successful rearing an oz. of seed produces about 14 seers of dry cocoons. At the rate of Rs. 30 per *seer* which was the rate in 1945 this means a gross income of Rs. 420 in about two-month period, which is a good financial help to a small peasant.

LAC

Lac is a resinous incrustation produced as a protective coating by an insect known as "Laccifer lacca" which feeds on the juice of such trees as *ber*, *dhak*, *chhichhra* or *palas*, *pipal*, fig, etc. In purified form this substance is known as shellac and is very extensively employed in the manufacture of varnishes, polishes and paints, sealing wax, bangles, gramophone records, jewellery and for colouring skins, etc. The value of this material is enhanced by the fact that no artificial product is known which can replace it. India holds a virtual monopoly for lac, accounting for nearly 85 per cent of the total world production.

For successful cultivation of lac equitable climate with a rainfall of about 30″ is necessary. Lac is, therefore, mainly produced in the sub-montane districts of Hoshiarpur, Kangra, Ambala and Gurdaspur in the Punjab. Una teshil of Hoshiarpur district is by far the most important. As a whole, however, this province occupies a minor position in India, producing only about 200 tons of lac, out of a total production of about 48,000 tons for the country. Nearly the whole of it is exported, mainly to the United Kingdom and United States of America. Besides India's own production, until recently the bulk of stick lac (6,000 tons) production in Burma, Siam and Straits Settlements found its way to India. After meeting the export requirements, India on an average, used only 4,000 tons of lac annually, but since the outbreak of war the quantity consumed in India has increased considerably.

The cultivation of lac is carried on by the inoculation of host plants and cutting the branches on which the lac encrustations have been formed. The lac insect produces two generations in a year. During the months of June-July the new brood appears and begins to crawl on the branches of the host trees. As soon as the insect finds a succulent twig it punctures it with its proboscis and settles down. It sucks the sap of the tree and exudes resinous material from the pores of its back. Thus, each insect forms around itself a covering independent of others. From outside, however, the incrustation gets mixed up to such an extent that it looks like one continuous layer. After a period of two months the male insect emerges from its cell, fertilizes the females and dies. The females after fertilization grow and exude lac at an accelerated pace while eggs ripen in their bodies. During October-November the second brood appears and the life-cycle is repeated. Each female lays numerous eggs and the insects swarm in hundreds of thousands, *i.e.*, *lakhs*, thus giving the product the name of *lakh* or *lac*.

Infection is carried out in two ways, *i.e.*, artificially and naturally. In the case of first method, a few sticks of brood lac, *i.e.*, lac from which larvae are about to emerge, are tied to the host tree suitably pruned, before hand. *For October-November inoculation, ber trees* should be pruned in June. When swarming has finished, the brood lac sticks should be removed from the tree and lac scraped off. For natural infection, all or a part of the lac encrustation on the host plant is left on branches and larvæ after swarming settle down on new shoots and branches.

There are two crops of lac in the Punjab—*Katki* and *Hari*. In the case of former trees are infected during June-July while in the case of latter in October-November. Harvesting is done in summer from first June to 15th July and in winter from 1st October to 15th January. After the lac-bearing twigs and branches have been cut from the trees, lac is scraped from them and sold as stick lac. After drying for a few days, the freshly-scrapped lac is winnowed to separate pieces of bark, wood and other extraneous matter. It is then passed through sieves of different meshes so as to grade it. The cleaned lac is then washed by sprinkling water over it and working the material vigorously under the feet. Later on, more water is added and after working it is allowed to stand. The grains of lac settle down and impurities float on water. The water is then strained and *pana* (seed) lac is obtained. After one washing, however, grains still contain some colouring matter and to get rid of this, second washing is necessary. In this case sometimes *sohaga*, (Borax), *saji* or soda ash is also added in small quantity. The *pana* after this washing is spread out to dry. Seed lac is about 66 per cent. of the weight of stick lac.

In order to prepare shellac the resin is extracted from the seed lac either by means of suitable solvents in a factory, or by melting the seed lac filled in long cloth bags over fire. The lac oozes out after melting and is removed with a blunt knife on to a flat smooth stone slab moistened with water. The molten resin is stretched into a thin sheet which after cooling is broken into small pieces. For manufacturing button lac the stretching process is dispensed with and molten lac is shaped into circular button-shaped cakes. Resin and orpiment are added for preparing various grades of shellac.

Income.

The yield of crude lac varies with the type of tree. *Ber* tree might give only about 8 *seers*, while *pipal* tree as mnch as 20 *seers*. On an average, however, a yield of 10 *seers* per tree can be safely expected. Taking the price at Rs. 60 per *maund*, a tree would give a gross return of Rs. 15 per annum. If a zamindar owns about 20 trees, his gross return would be somewhere near Rs. 300. This is practically his net income, because, the cost of lac cultivation to an ordinary farmer owning 10 to 20 trees and possessing his own brood lac is practically nothing. Pruning and inoculation of trees can be easily attended to by the cultivator himself with the help of his family members.

DAIRY FARMING

Milk as Food.

Milk contains in a highly digestible form all the essential constituents of food-proteins, carbohydrates, fat, mineral matter and vitamins, required for the growth and maintenance of the body. It is, thus, a complete food for children and an excellent complementary food for all ages and conditions of life, especially for the old, invalids and pregnant and suckling women.

The following figures give the amount of milk consumed in India and some of the other advanced countries of the world:—

Country	Milk consumed per head per day
	oz.
Finland	63
Newzealand	56
Australia	45
Great Britain	39
U. S. A.	35
Germany	35
India	7

If the above countries were our only standards then India comes off very badly. The figures for China and Japan are not easily available, but in the latter country though highly industrialized the consumption of milk is very small. As explained elsewhere in this book we advocate grain and vegetable production as priority No. 1 for India.

In spite of this India needs to be more efficient as a milk producer. "India has as many milch cattle as Europe including Russia "but the production of milk is only 20 per cent of that of Europe. Both, the type of animal kept is poor and the feeding unsatisfactory. Milking capacity is determined by inheritance. Selective breeding gives the best results combined with proper feeding.

The following figures relate to pre-war conditions:—

Milk yield per animal per day	Cost of Feeding	Overhead charges	Cost per *seer*
Seers	Rs. a. p.	Rs. a. p.	Rs. a. p.
5 ..	0 7 3	0 3 0	0 2 0
10 ..	0 9 8	0 3 0	0 1 3
15 ..	0 12 0	0 3 0	0 1 0
20 ..	0 14 5	0 3 0	0 0 10

It would be observed that higher the milk yield per animal, the lower is the cost of production per *seer*. The improvement in the milking capacity of our animals calls for a country-wide campaign in favour of systematic breeding and feeding on improved lines. In this connection it would be interesting and instructive to show the improvement made in the Lyallpur College Dairy herd during the last 30 years:—

Year	YIELD PER DAY PER ANIMAL (IN POUNDS)	
	Cows	Buffaloes
1914-15	5.6	..
1919-20	8.6	..
1924-25	9.03	..
1929-30	11.4	..
1934-35	16.53	..
1939-40	18.74	12.59
1944-45	15.64	15.52
1945-46	16.04	12.37

Buffaloes give milk with 50 per cent more fat than cows and have for generations been subjected to selective breeding. The average standard in the case of buffaloes is much higher than in that of cows.

Milk marketing.

There is much room for improvement here*. One of the first reforms must be elimination of cows and buffaloes keeping in town areas. At present more than half the milk consumed in our towns is produced on the spot. We need more distribution centres, better transport arrangements and a law to penalize watering and adulteration. As milk will remain a very vital and important food for towns the reorganization contemplated here is long overdue.

POULTRY KEEPING

The total number of poultry birds in the Punjab during the year 1944-45 was estimated 3.7 million. Of this about 1.7 millions were hens, 0.4 million cocks and 1.6 millions chickens. The number of ducks, drakes

*See Report on Milk Marketing in India and Burma for further details.

and ducklings is less than 50,000. In spite of such a large number of birds, the production of eggs is low, *viz.*, only 94 *million eggs*. Throughout the province, mostly *desi* hens of mongrel type are kept, which produce annually about 55 eggs each. Production is very low in comparison with other countries, as shown below:—

Country		Average number of eggs produced per hen per annum.
Netherlands ..	..	125
Northern Ireland ..	..	122
Irish Free State ..	..	121
England and Wales	..	120
Scotland ..	..	118
Belgium ..	..	116
Estonia ..	..	108
Japan ..	..	103
India ..	..	55 (*Desi* hens only).

The important districts where poultry is kept in the Punjab are Rawalpindi, Jhelum, Attock, Gujrat, Multan, Dera Ghazi Khan, etc. From some of these towns, large number of eggs and birds are sent to large cities and towns, such as Lahore, Delhi, Karachi, Bombay, etc. It is, however, a well-known fact that the quality of our eggs and poultry is low and the vast majority of poultry is kept by the lower classes of people and not by cultivators as in China. Even these classes of people do not pursue this occupation as their main occupation, but practise it as a subsidiary industry and this is probably sound. The majority of farmers regard poultry-keeping below their dignity and others avoid it on religious grounds.

Poultry-keeping is, thus, in a sadly neglected and backward condition. The main reasons for this are:—

(1) defective feeding and keeping conditions,

(2) lack of well-defined breeds of poultry,

(3) diseases, and

(4) defective marketing practices.

Defective housing, feeding and breeding are also responsible for the low qualities of poultry birds in the

Punjab. The ordinary poultry house or *khudda* in a village is nothing short of a death trap. The poultry house (*khudda*) is seldom cleaned and is, therefore, a veritable store house of diseases. *Tokras* and *chhikus* are also used. Though better than *khuddas*, they expose the birds to enemies and rigours of the elements. Essential principles of housing in the case of fowls are dryness, protection from enemies and natural elements, ventilation, freedom from parasites, ease of disinfection and economy. A simple house, made of iron and cement, will meet all these requirements. In order to avoid the extremes of heat or cold, a thatch-covering should be provided. It should be able to accommodate one cock and 12 hens.

The general system in the villages is to let the fowls feed for themselves on whatever they can pick up from the kitchen refuse, the village dust heap or the cattle yards. Young chickens are given some grains for feeding, but as soon as they are big enough to roam about they are left to eke out their sustenance for themselves. Without proper feeding it is impossible to improve the poultry.

The common fowl, met with in the village is mongrel, which answers to no single description and possesses no definite qualities or characteristics. The only redeeming feature of this fowl is its hardiness to withstand diseases as compared with the improved foreign breeds. The main task of poultry breeding research in the Punjab, therefore, is to select fowls of promising traits and by careful breeding and continuous selection evolve distinct breed or breeds which will answer to definite points of quality and utility. Two such breeds, namely the Punjab Black and the Punjab Brown have been evolved at the Gurdaspur Poultry Farm. The improved Punjab Black is essentially an egg-laying strain; though its body weight is also somewhat heavier than the average village Mongrel. This type of fowl gives an annual production of 81 eggs against 46 eggs from the village Mongrel. The average weight of egg is also slightly higher. Average body weight of male is 5 lbs. 2 ozs. as against 4 lbs. 4 ozs. of a Mongrel. The improved Punjab (Reddish) Brown is essentially a ;able fowl though its egg laying capacity is also better than *Desi* hen—68 as against 46 eggs. Average egg weight and body weight are also higher.

Although these strains have been evolved, yet they have not attained any commercial importance in this province. The famous "fighting cock", *Asil*, is found in scattered manner in some districts of the Punjab, especially those in the South-West such as Multan, Muzaffargarh, Dera Ghazi Khan, Mianwali, etc. This breed is kept mainly for its fighting quality. It also forms a superb table fowl. *Asil* hens lay very few eggs (only 35 per annum) and are inclined to excessive broodiness, but they are good for hatching purposes. The Chittagongs have also been introduced in this province. Their number is, however, small. It is a dual purpose breed. The size of egg is, however, smaller than that in the case of *desi* hen.

The four breeds of foreign origin found in the Punjab, *viz.*, the White Leghorn, the Black Minorca, the Rhode Island Red and the Light Sussex, have no commercial importance at present , though some poultry keepers keep these breeds. Under better housing and feeding conditions these breeds lay a larger number of eggs than the *desi* fowl, and some of them, *viz.*, the Rhode Island Red and the Light Sussex form superb table fowls. They, however, cannot withstand the severe local conditions to the same extent as *desi* fowl. They are also more prone to diseases. While Black Minorca is noted only for large size of eggs, the White Leghorn also lays higher number of eggs. The latter is also a hardier breed and can stand village conditions comparatively better. Pure white colour of the chicks is, however, a great attraction to the kites, hawks, and crows and unless the young ones are protected, losses from this source are likely to be heavy.

The incidence of disease constitutes another chief factor responsible for the poor condition of the Punjab fowl. The eradication of disease from the poultry population is one of the outstanding problems that await solution "Ranikhet" is the most dangerous disease. Fortunately inoculation has recently been discovered which is said to be very effective.

The marketing of poultry and eggs is very defective. The produce is marketed in dirty condition. In the egg trade, ordinary *tokri* made up of *pilchhi*, mulberry sticks or bamboo, is the chief container used even for export and import. Eggs are put in the baskets without any stuffing material. This results in heavy losses in transit. The agencies in the system of distribution are also very expensive with the result that the producer gets a low share of the consumer's rupee. There are no recognized market standards for sale with the results that the quality fetches little or no premium. With a view to improving the conditions of the poultry industry, it is essential to put the trade on sound lines.

Future Policy.

A large amount of food goes to waste in all parts of the province where poultry are not kept. On the other hand if large numbers are kept by the individual and regular feeding given, the cost and incidence of disease is high. The best policy is, therefore, to aim at each cultivator keeping from 6 to 12 birds only. Some form of moveable coops, whereby gleaning after harvesting could be partly left to fowls, is needed. Then again in areas where poultry keeping is an important industry we need to develop artificial incubation of eggs. In China as many as 3,000 eggs are hatched at one time in low-roofed huts with charcoal or kerosene as the only heating mechanism. The chicks are sold for rearing by farmers. There is much scope in the Punjab for development along these lines.

SHEEP AND GOATS

Sheep and goats form an integral part of the rural economy of the Punjab, as is clear from the fact that their number constitutes about one-third of the total livestock population of the province and they form the second biggest group after the bovines. According to 1940 Census there were 8.8 million sheep and goats in the Punjab, the number for the sheep being 5.3 million and that for goats 3.5 millions. Though these animals are found in every part of the province, yet from the point of view of density in relation to human population and area they are concentrated more in the North and South-Western portion of the Punjab than in other areas of the province. Their number is lowest in the Central Punjab districts, whilst the Hariana and Malwa tracts occupy an intermediate position. The provision of meat (mutton and goat flesh) for human consumption constitutes the most important aspect of the bovine industry in the Province. This is, however, most expensive, as nearly one-third of the total population of sheep and goats are killed every year for this purpose and the heavy drain is made good partly by imports from the neighbouring territories of the North-Western Province and partly from large number of births. Goats are also valuable milk yielding animals. Their milk contains about 4.5 per cent fat and it is stated that its casein is digested in one-third time required for the digestion of cow's milk and that on the addition of five per cent sugar it becomes identical with the human milk. Its fat globules are also smaller than those in the cow or buffalo's milk and are, therefore, much more easily digested. Goat's milk has also an alkaline reaction during digestion, which is not true of other milks. This is a valuable property, for it helps to kill germs found in such diseases as common colds, influenza, etc. Goats eat a variety of food which imparts valuable properties to their milk. It is very rare indeed that goats are affected by tuberculosis. These factors increase the value of goat's milk a good deal which is thus highly suited for children, invalids and aged people. Apart from meat and milk, sheep and goats provide valuable manure, wool, hair, skins and guts.

Sheep and goats are largely kept by poor and illiterate class of people. The higher classes of zamindars consider it below their dignity to own these animals. They are also very destructive to the ordinary farm crops, small trees and shrubs, if allowed to roam at large. Besides, these animals especially sheep, are very susceptible to diseases and require special care. For these reasons they are not generally popular with the ordinary farmer. However, some of the nomadic graziers and *gujjars* in the towns possess sheep and goats of high quality. The *Bikaneri* sheep possessed by the wandering tribe of Ods in the Malwa tract and *Gaddi* sheeps by *Gaddis* of Kangra hills are notable examples. The *Bikaneri* sheep yields large quantity of wool and the *Gaddi* sheep produces best quality wool which is used for the manufacture of the famous Kulu *lohis* and *pattis*. The chief wool market for *Bikaneri* wool is Fazilka. During the war the blanket industry has developed a good deal at Panipat, with the result that this has also become an important wool market now. The system of wool marketing, however, requires considerable improvement. At present wool of various colours clipped from different parts of the body is mixed together and sold in the market. If, however, wool of different colours is kept separate and is removed from the body of the animal after washing it, it would bring better return to the wool producers. Further, the wool from lambs should be kept separate from that of full-grown sheep. The body wool should also be kept separate from that obtained from other parts of the body such as legs and head which is courser and shorter.

There are several kinds of goats in the hills and in the Punjab plains. Of these, *Betal* or *Jamna Pari* is the most important. The hill goats give low milk yields but their hair is valued for making ropes, bags, mattresses, etc. The *Betal* or *Jamna Pari* breed of goat is mostly kept for milk production. Its hair is short. The colour is generally red tan and black. It gives two to four pounds of milk daily. At the Hissar Cattle Farm the *Jamna Pari* goats are also being kept for purposes of breeding and research.

With a view to supplying good rams for the improvement of village flocks the Punjab Government have evolved a breed known as *Hissar dale* by crossing the imported Merino rams with the local *Bikaneri* and *Bagri* ewes. These are being distributed in the Punjab to bona-fide breeders at special rates. Besides this, about 158 sheep breeding units, each consisting of 50 ewes and one ram of improved type have been distributed to the bona-fide sheep breeders in the province on a system by which a proportion of the young become the property of the breeders. In order to bring about rapid improvement in the sheep and goat keeping it is, however, essential to intensify the work further.

Future possibilities.

Large flocks of sheep are moved during the summer to graze in the Himalayas in Kangra and Kulu, etc., to utilize pasture which would otherwise be wasted. In the autumn these are brought down to the Punjab plains. If we could develop a cold storage and export business for frozen mutton and lamb there would be a good scope for stall feeding sheep in the plains. The sheep would be bought in October in Kangra and railed to the colonies and stall fed. It takes 10 lbs. of dry matter to get one pound of mutton—so this processing would reduce the exportable surplus of say gram and convert it into much more valuable and concentrated food in the form of meat. An export trade is essential to evolve such an industry to stabilize itself and progress normally. A very much larger number of sheep could be grazed in the Himalayas if there was a regular outlet for the sheep for winter feeding in the plains.

APPENDIX

Estimated Income and Expenditure from dairy farming from one square of land.

Assumptions—

1. Land is owned and canal irrigated.
2. Distance—7 miles from a town where milk is to be sold.
3. Young stock not to be reared. Replacement to be made by purchase.
4. Only green fodder to be raised from land, other feeding stuffs to be purchased.

Land—

One square (28 acres)	
Area under roads and buildings ..	3 acres.
Area under fodders ..	25 acres.
Intensity of cropping ..	120 per cent (on the basis of fodder area of college dairy, though under *zamindara* conditions it is less).
Average yield of fodder crops (All crops considered) ..	350 mds. per acre (on the basis of fodder area of college dairy).
Total area of fodder grown ..	$\frac{25 \times 120}{100}$ is equal to 30 acres.
Total yield of fodder ..	$30 \times 350 = 10{,}500$ *mds.* say 10,000 *mds.*

Fodder required for one head of cattle daily 25 *seers.*

The No. of cattle that can be fed .. $\frac{10{,}000 \times 40}{25 \times 365} = 43.$

The details of animals are given below:—

Cows	35	The young stock is not included because it has to be disposed of as soon as weaned at birth if possible or at the age of six months at the most.
Bullocks	6	
Bull	1	
Tonga pony	1	
Total	43	

Initial Expenditure—	Rs.	a.	Rs.	a.
(1) Livestock: 35 cows at Rs. 300 each	10,500	0		
6 bullocks, at Rs. 400 each ..	2,400	0		
1 bull, at Rs. 500 each	500	0		
1 Tonga-pony, at Rs. 300 each ..	300	0	13,700	0
(2) Buildings (Kacha building with pacca floors).				
Cow shed for winter 126′ × 16′ (3′ manger, 5′ standing place, 1½′ gutter, 3½′ passage, 3′ walls) Rs. 2 per square foot	4,032	0		
Winter shed for bullocks and pony— 15′ × 31′ at Rs. 2 per square foot. ..	930	0		
Bull shed (roofed portion) 15′ × 10′ at Rs. 2 per sq. ft.	300	0		
Milk recording room (kacha, pacca) 12′ × 12′, at Rs. 5 per sq. ft.	720	0		
Washing room, (kacha, pacca) 12′ × 12′, at Rs. 5 per sq. ft.	720	0		
Enclosure walls, etc.	500	0		
Two stores 18′ × 18′ each at Rs. 2 per sq. ft. ..	1,296	0	8,498	0
(3) Cultivation machinery and implements, etc.				
3 Desi ploughs, 4 yokes, 1 Hindustan plough, 2 Lyallpur hoes, 1 bar harrow, 1 *Sohaga*, and 1 karah	200	0		
2 Carts at Rs. 400 each	800	0		
1 bullock gear chaff-cutter	600	0		
1 tonga	600	0		
Hand tools	100	0	2,300	0
(4) Cattle-yard and other equipment—				
50 chains at Rs. 7 each	350	0		
20 buckets at Rs. 6 each	120	0		
3 milking pails at Rs. 15 each	45	0		
1 Dairy herd recorder at Rs. 90	90	0		
1 strainer at Rs. 50	50	0		
10 Milk cans of various capacities at Rs. 40 each ..	400	0		
1 tatooing set	100	0		
Ropes, bags, and other miscellaneous goods ..	300	0		
6 wooden mangers at Rs. 50 each	300	0	1,755	0
	Total ..		26,253	0
	or Say:		26,500	0

Expenditure Per Annum—

	Rs.	as.	Rs.	as.
(1) Interest on Rs. 26,500 at 4 per cent.			1,060	0
(2) Depreciation:				
12 per cent. on Rs. 13,700 (livestock)	1,644	0		
6¾ per cent. on Rs. 8,498 (Buildings)	566	0		
20 per cent. on Rs. 90 (ploughs, yokes, *sohaga*) ..	18	0		
10 per cent. on Rs. 2,110 (other implements) ..	211	0		
10 per cent. on Rs. 685 (pails, cans, tatooing set strainer and dairy herd recorder)	68	8		
20 per cent. on Rs. 300 (wooden mangers) ..	60	0	2,567	8
(3) *Feeding Stuffs*:				
(*i*) Green fodder	Rs.			
Water rates ..	75	0		
Revenue at Rs. 5 per acre ..	140	0		
Seed at Rs. 8 per acre ..	240	0	455	0
(*ii*) Concentrates 800 mds. at Rs. 6-8 per md. ..	5,200	0		
(*iii*) *Bhusa* at 4 seers per animal daily 1,570 mds. at Rs. 1-8 per maund ..	2,355	0		
(*iv*) Common salt 25 mds. at Rs. 2-10 per maund ..	66	0		
(*v*) Medicines, etc.	100	0	7,721	0
(4) *Labour*—				
3 milkers, 2 men for cultivation, 3 men for fodders at Rs. 30 per month each	2,880	0		
2 sweepers at Rs. 25 per month each	600	0		
1 delivery man at Rs. 30	360	0		
Casual labour	150	0		
1 *munshi* at Rs. 35	420	0	4,410	0
(5) *Miscellaneous Expenses*				
Bags. Rs. 75; Ropes. Rs. 50; Chains. Rs. 50; Hand tools. Rs. 50; Buckets Rs. 60; Soda. Rs. 40; Fuel. Rs. 150; Stationery. Rs. 20; Soap. Rs. 10; Kerosene oil. Rs. 70	575	0		
Repairs to buildings. Rs. 200; Implements. Rs. 50 ..	250	0		
Other miscellaneous expenses	100	0	925	0
Total:			17,138	8
Total Expenditure. Or say:			17,200	0

Income Per Annum—

	Rs.	a.
3,000 lbs. milk per cow per year in addition to that sucked by the calf, at Re. -/2/3 per lb.	14,766	0
25 calves at Rs. 10 each (manure is to be added to fields.)	250	0
Total ..	15,016	0

Balance—

	Rs.	a.
Income	15,016	0
Expenditure	17,200	0
Net loss	2,184	0

Note.—This loss will be higher in case the young stock is not disposed of at birth.

Income and Expenditure from arable farming in one square canal irrigated land under direct cultivation.

Equipment required :

		Rs. a.	Rs. a.
(1) Livestock :			
	4 bullocks at Rs. 400 each		1,6000
(2) Dead stock Implements :			
Improved	Hindustan plough	25 0	
	Cart one, at Rs. 400	400 0	
	Single row cotton drill	12 0	
	Lyallpur hoe, 2 at Rs. 12/8/-	25 0	462 0
Indigenous	Munna ploughs, 2 at Rs. 14	28 0	
	Panjalies, 2 at Rs. 8-8	17 0	
	Karah 1, at Rs. 20	20 0	
	Sohaga 1	25 0	
	Fodder cutter at Rs. 40	40 0	
	Bar-harrow 1	23 0	
	One big Panjali	14 0	167 0
Gur Making	Cane crusher	400 0	
	Pan and grating	60 0	460 0
	Hand tools		211 12
		Total ..	2,900 12

INCOME

Crop.	Area (acres)	Yield per acre. (Mds.)	Total yield. (Mds.)	Rate per md.	Total amount.	
				Rs. a.	Rs. a.	Rs. a.
Sugarcane ..	1	40	40	9 0	360 0	
Maize—						
Grain ..	1	20	20	6 0	120 0	
Stalks ..	..	..	..	..	25 0	
Desi Cotton ..	½	7	3½	11 0	38 8	
American Cotton ..	4½	7	31½	16 0	504 0	
Cotton sticks ..	..	..	..	10 0 per acre	50 0	
Kharif fodder ..	2½	..	..	15 0 per *kanal*	300 0	
Wheat—						
Grain ..	12	16	192	8 8	1,632 0	
Bhusa ..	..	24	288	1 8	432 0	
Gram—						
Grain ..	2	12	24	6 8	156 0	
Bhusa ..	..	12	24	1 0	24 0	
Toria ..	2½	9	22½	14 0	315 0	
Rabi fodder ..	2	..	..	25 0 per *kanal*	400 0	4,356 8
					Or say	4,360 0

EXPENDITURE

			Rs. a.	Rs. a.
(1)	Manual labour—			
	(a) Permanent 3 men a year @ Rs. 360/- each ..		..	1,080 0
	(b) Casual (Payment in kind)		..	..
	Wheat—			
	16 bundles, Grain 6 *mds*.. 16 *srs*. at Rs. 8-8 per maund		54 6	
	Bhusa—			
	9 *mds*. 24 *srs*. at Rs. 1-8-0		14 7	
	Picking of cotton 1/10 share		54 4	
	Winnowing of wheat at 2 *srs*. per *md*.. (9 *mds*. 24 *srs*. at Rs. 8-8)		81 10	
	Gur to Jhoka—			
	1½ sr. per md. (1½ md.)		12 0	216 11
(2)	Upkeep of Bullocks—			
	Interest and depreciation at 16 per cent. Rs. 1,600 ..		256 0	
	Concentrates at 2 srs. per bullock per day (for 120 days 24 mds. at Rs. 8)		192 0	
	Green fodder (8 kanals *kharif*, and 8 kanals *rabi*) ..		320 0	
	Bhusa 3 srs. per bullock daily (110 mds. at Rs. 1-8) ..		165 0	
	Miscellaneous (salt, medicines, etc.)		20 0	
	Interest on bullock-shed 6¼ per cent.		51 5	
				1,004 5
(3)	Implements and hand tools—			
	Depreciation on Rs. 462 at 10 per cent.		46 3	
	Depreciation on Rs. 167 at 20 per cent.		33 6	
	Depreciation on cane crusher at 10 per cent. .. Rs.	40		
	Grating and pan at 20 per cent. .. .. Rs.	12		
	Rs.	*52**	*10 6*	
	*This is to be divided by 5 as one crusher can crush 5 acres crop in a season			
	Interest		52 0	
	Repairs and replacements		20 0	161 15
(4)	Seed—			
	Wheat 8 *mds. 16 seers* at Rs. 8 a *maund*		67 0	
	Gram 32 *seers* at Rs. 6 per *maund*		5 0	
	Sugarcane 16 *marlas*		32 0	
	Cotton seed 1 *md*. at Rs. 8 per *maund*		8 0	
	Maize 8 *seers* at Rs. 5-8 per *maund*		1 0	
	Chari 1½ *md*. at Rs. 8 per *maund*		12 0	
	Guara, 20 *seers* at Rs. 8 per *maund*		4 0	
	Toria, 6½ *seers* at Rs. 14 a *maund*		2 3	
	Berseem, 16 *seers* at Rs. 1-8 per *seer*		24 0	155 3
(5)	Village artisans		..	40 0
(6)	Water rates		..	121 10
(7)	Land revenue and cesses		..	140 0
			Total ..	2,919 12
			Or say ..	2,920 0
	Balance—			
	Gross Income		4,360 0	
	Gross Expenditure		2,920 0	
	Net Income		1,440 0	

References

1. Progress of Bee-Keeping in the Punjab, by Dr. Khan A. Rahman.

2. Hints on Silk-Worm Rearing in the Punjab, by Madan Mohan Lal.

3. A Preliminary Report on the Extension of Sericulture in the Punjab, by M. Afzal Hussain.

4. A Report on the Marketing of Lac in India.

5. Economics of Lac Industry in the Punjab, by R. L. Anand, (Board of Economic Inquiry, Publication No. 47).

6. A Report on the Marketing of Eggs in India and Burma.

7. A Report on the Marketing of Milk in India and Burma. (Second Edition).

8. A Report on the Marketing of Sheep and Goats in India.

9. Punjab Dairying (Urdu), by Sardar Bahadur S. Kartar Singh.

10. Report on the Development of the Cattle and Dairy Industries of India, by Norman C. Wright.

11. Cost of Milk Production at Lyallpur, Punjab (1930-31), by D. P. Johnston and S. Kartar Singh (Board of Economic Inquiry Publication No. 25).

12. Cost of Milk Production at Lyallpur, Punjab (1931-32 to 1934-35), by S. Kartar Singh and L. C. Sikka, (Board of Economic Inquiry Publication, No. 55).

13. Keeping Milk Goats in India, by Coheen.

14. The Economic Value of Goats, by H. R. Stewart (The Board of Economic Inquiry Publication, No. 8).

GLOSSARY OF VERNACULAR TERMS

Abi—Land watered by lifts from tanks, pools, marshes or streams.

Abiana—Water rates.

Adrak—Ginger (Page 378).

Akasbel—Cuscuta (*Cuscuta reflexa*).

Anhi Godi—Blind hoeing. A hoeing (generally given to sugarcane) before the hoots appear above ground.

Anjan—A nutritious grass (Page 475).

Anna—One sixteenth of a Rupee.

Arhar—Pigeon pea (*Cajanus Indicus*) (Page 293).

Arhtya—A commission agent in a market.

Arli—Wooden or iron pin in a yoke to prevent bullocks from getting unyoked (Page 111).

Arvi—Arum (Page 377).

Asil—A breed of fowls well known for its fighting qualities.

Ata—Wheat or any other grain flour.

Badshah—A king.

Bagri—A type of sheep (Lit. Pertaining to Bagar, a tract bordering on Bikaner).

Baguri—A hand hoe for blind hoeing sugarcane (Page 113).

Bahaduri—Gram caterpiller (Page 300).

Baingan—Brinjals (Page 369).

Bair—(Also *Berh*). A drum in persian wheel carrying the *mahl*, *i. e.*, bucket chain (Page 142).

Bajra—Bulrush or spiked millet (*Pennisetum typhoideum*) (Page 278).

Bajri—Small seeded *bajra*.

Bakarbel—Lehli, a weed (Page 217).

Bali—A type of *Kodra* (Page 284).

Balkhi Tambaku—A type of tobacco (Page 480). The same as *Gobhi tambaku*.

Balti—Bucket.

Banaspati Ghee—Ghee prepared artificially by the hydrogenation of vegetable oils.

Band Gobhi—Cabbage (Page 361).

Bania—A caste of Hindus usually doing business. A village shop-keeper or a money-lender.

Banjar—Uncultivated land.

Bar—An arid tract.

Bara (Rice)—The same as *Hansraj*.

Bara (Soil)—A hard type of heavy alkaline soil, very impervious to water (Page 42).

Barani—Dependent on rain. Unirrigated.

Bari (soil)—Soil similar to *bara* but less hard.

Barfi—*Gur* in the form of slabs in a single layer (Page 319).

Baru—A weed (P ge 210).

Basin—Gram flour.

Basmati—A fine variety of rice (Page 255).

Batai—The system of farming where the rent is a certain proportion of the produce, *c. f.* Metayer system.

Bathu—A weed (Page 215).

Bauphali—A weed (Page 214).

Begar—Compulsory labour.

Bela (River)—Uncultivated pieces of land lying in river beds.

Belcha—A type of spade (Page 113).

Belna—Cane crushing mill (Page 102).

Bengals—Commercial name of a low grade Indian Cotton.

Ber—*Zizyphus Jujuba.*

Berh—See *Bair.*

Berrara—Wheat and gram mixture.

Berseem—Egyptian Clover, a fodder crop (*Trifolium alexandrinum*) (Page 463).

Bet—Riverain tract.

Betal—A type of goat (Page 553).

Bhadwari—Pertaining to Bhadon, a month in Indian Calendar comprising later half of August and earlier half of September.

Bhakra—A weed (Page 214).

Bhandaur—The giant honey bee (Page 536).

Bhang—Indian hemp (Page 501).

Bhari—A bundle.

Bharola—A cylindrical mud-bin used for storing grain.

Bheli—A lump of gur (Page 318).

Bhindi—Lady's finger (Page 374).

Bhres—(*Fygopyrom sp.*)

Bhugat—A weed (Page 215).

Bhurat—A weed (Page 214).

Bhusa—Straw crushed and broken into short lengths by trampling with bullocks during the process of threshing.

Bhusa missa—Crushed gram straw after threshing.

Bikaneri—A breed of sheep.

Biri—A type of cigarette in which tobacco is wrapped in a leaf.

Bora—A large-sized bag used for transporting cotton, etc. (Page 430).

Bukhari—A store made by constructing two mud-walls in a corner of a room for storing grain.

Bund—An earth ridge dividing two fields or irrigation beds (Kiaras or kiaris).

Buin—A weed (Page 214).

Candy—The Bombay candy of cotton is 784 lbs or 9½ mds. of lint or two bales net.

Chai—Tea (Page 490).

Chahi—Well-irrigated.

Chet—15th of March to 15th of April. Name of an Indian month.

Chak—A group of rectangles or squares in Canal Colonies: practically equivalent to a village.

Chakki—Grinding mill.

Chakla—Horizontal gear wheel in persian-wheel (Page 142).

Chakli—Vertical gear wheel in persian wheel (Page 142).

Chaku—A form of *gur* in the form of slabs with three or four layers which can be separated with a sharp-edged knife.

Chana—Gram (Page 296).

Chandni—A weed (Page 219).

Chapati—A thin unleavened cake prepared from wheat or other type of flour.

Chaqander—Beet (Page 366).

Charas—A resinous substance exuded by Indian hemp (*bhang*) after spontaneous rupture of the bark just before the maturing of flowers. It is smoked as a narcotic.

Charkha—A spinning wheel.

Charsa—A leather bucket used for lifting water for irrigation purposes (Page 150).

Chawal—Rice (Page 253).

Chausera—A form of *gur* in *bhelis* of four seers each (Page 319).

Cheena—Panicum miliaceum (Page 283).

Chhaj—A special type of basket used for winnowing.

Chhatta—Method of sowing by broadcasting the seed.

Chhikku—A kind of basket.
Chhiklis—Bullock muzzles.
Chirwa—A preparation in which rice is boiled in water, subsequently left in this water for 3 or 4 days and then pressed flat by means of a pestle.
Chow—Wooden breast or mouldboard of *munah* plough (Page 72).
Chhoti makhi—The little honey bee (Page 539).
Chuha-ramba—A hand tool for digging holes in the ground.
Chulai—A weed (Page 214).
Cusec—Cubic foot of water per second.
Dabbal Roti—English type of bread.
Dab—System practised in connection with seed-bed preparation of wheat for controlling early *rabi* weeds (Page 59).
Dabh—A weed (Page 211).
Dal—Split pulse with or without husk (Page 287).
Dalia—Crushed grains for gruel or pudding.
Dandal—A pegged sohaga.
Darohla—The Indian honey bee (Page 536).
Daryai booti—A weed (Page 213).
Dati, *Datri*, *Daranti* } See *dranti*.
Darrar—Land rendered unfit for cultivation by deep gully erosion.
Desi—Indigenous (Lit. pertaining to country).
Dhabhar—A weed (Page 219).
Dhaman—The same as *Anjan* (Page 475).
Dhan—Unhusked rice.
Dhanya—Coriander (Page 380).
Dhar—Long low heap of stored bhusa covered with mud.
Dharwar—Part of Bombay Presidency growing American Cotton since 1860, (P. 132).
Dhaulu—A local type of sugarcane (Page 308).
Dhaulphuli—A weed (Page 214).
Dhenkli—(Also *Dhingli* A water lift. Counter poise lift (Page 145).
Dila—A weed (Page 213).
Doab—A tract of land between two rivers.
Dodder—A weed (Page 219).
Dodhak—A weed (Page 212).
Doka—Fresh dates (Page 355).
Dora—A ladel used for transferring sugarcane juice from one pan to the other (Page 114).
Dranti—Also *datri* or *dati*, sickle.
Dub—A weed (Page 209).
Dudhi—A weed (Page 212).
Dumna—The giant honey bee (Page 535).
Dussehri (Mango)—A type of Mango (Page 352).
Duty—A technical irrigation term to express relation between area irrigated and water used, usually a cusec.
Fakir—A beggar.
Falsa—*Grewia asiatica* (Page 339).
Farid buti—A weed (Page 219).
Fellah—Egyptian cultivator.
Gaddi—A tribe of shepherds belonging to Kangra Distt. Also breed of sheep kept by the same.
Gadoa—A wooden stirrer used for *stirring boiling sugarcane juice.*
Gainti—A pick axe (Page 113).
Gajar—Carrot (Page 365).
Gand—*Gur* making circular pan usually made of earth or wood.
Gandali—See *chuha-ramba* (Page 113).
Gandasa—Hand chopper. Also called *Toka.* (Page 113).
Gandh Gobhi—Knol Khol (Page 362)
Ganja—Young female flowers of Indian hemp (bhang). It is smoked as a narcotic.
Ganna—Sugarcane (Page 306).

Ghanwan—A hand tool for stirring sugarcane juice in the boiling pan (Page 114).

Gharat—A water mill.

Ghat—A preparation from barley for which barley is moistened, heaped as such for a night, roasted next morning and husked.

Ghaya Kaddu—Bottle gourd (Page 374).

Ghaya Tori—Luffa or sponge ground (Page 376).

Ghora—Sugarcane Pyrilla (Page 316).

Ghundis—Small pieces of hard stems of gram.

Gobhi—Cauliflower, cabbage and knol khol.

Godi—Interculture.

Goji—Gram and barley mixture.

Gora—Whitish.

Guara—Cluster bean (Page 457).

Guncha Gobhi—Brussel's sprout (Page 302).

Gur—Raw sugar in lumps.

Hakim—A physician practising in Indian system of medicine.

Hal—A form of indigenous plough, also called *desi* plough.

Hals—Beam of an indigenous plough, *i. e.*, *munah* or *desi* hal (Page 72).

Halwa—A preparation in which wheat flour is fried in ghee and then sweetened with solution of sugar.

Halwa Kaddu—Red gourd (Page 375).

Hansraj—A fine variety of rice (Page 255).

Hathi—Handle of a plough (Page 72).

Hathi Ghas—Elephant grass. (Page 477).

Haq—Right, generally percentage area of irrigation guaranteed.

Hazardana A weed (Page 212).

Hithar—Low-lying land.

Hillawi—A variety of dates.

Hukka—Indian smoking pipe.

Hulhul—*Cleome sp.* (Page 207), a weed.

Ikadshi—Eleventh day of each half of the Indian lunar month.

Ikh—Sugarcane (Page 306).

Isapghol—Plantago.

Itsit—A weed (Page 212).

Jala—*Hydrilla verticillata* (Page 320).

Jaman—*Eugenia* Sp.

Jamna pari—A breed of goats (Page 553).

Jandra—A hand tool used for making *bunds* (ridges) (page 114).

Jangli—Wild. An original inhabitant of canal colony tract.

Jangli jut—A weed (Page 212).

Jangli Palak—A weed (Page 214).

Jangli Swank—A weed (Page 214).

Jau—Barley (Page 253).

Javi—Oats (Page 459).

Jhallar—Form of persian-wheel used for lifting water from shallow-depth. (Page 141).

Jhiwar—Water carrier caste.

Jhoka—Fireman.

Jhona—A coarse variety of rice.

Jhul—Rough covering for bullocks to protect them from cold in winter.

Jowar / *Juar* } *Andropogan Sorgham* (Page 275).

Jula—The yoke of the cart (Page 110).

Jungle—A forest.

Kabuli—Pertaining to Kabul in Afghanistan.

Kabuli Chana—A bold type of gram.

Kachcha—Unripe; Unburnt; made of mud; unmetalled.

Kahi—A spade (Page 113). Also called *kasi*.

Kahu—A local type of sugarcane (Page 308)

Kainth—*Pyrus Sp.*

Kala karwa—A type of *Hukka*

tobacco.

Kali—Black.

Kallar—Also *reh* or *usar* : alkaline, incrustation on soil. Also alkaline soil.

Kalrathi—Heavy alkaline soil.

Kamad—Sugarcane (Page 306).

Kamin—A village menial.

Kan—An accessory part of a cart (Page 110).

Kan—Proportion of lint in seed-cotton.

Kanak—Wheat (Page 220).

Kanal—1/8th of an acre.

Kangni—*Setaria italica* (Page 282).

Kanungo—A revenue officer supervising the work of patwaris.

Kapara—A mixture of white flowered indigenous cotton grown in the sourthern portion of the Ferozepur distt. and adjoining areas of the States.

Kapas—Seed cotton.

Karaha—An implement worked by two pairs of bullocks and used for levelling land (Page 89).

Karahi—A smaller *karaha* worked by one pair of bullocks.

Karand—Also called *papri*, hard crust formed on the surface of soil after rain or irrigation.

Karela—Bitter gourd (Page 375).

Karbi—Dry *jowar* stalks after the removal of ears.

Karir—*Capparis aphylla*. A bushy plant found in arid tracts.

Kashmiri—Pertaining to *Kashmir*.

Kasi—See *Kahi*.

Kasmal—*Berberis Sp.*

Kasni—Chicory (*Cichorium intybus*).

Kasola—A hand tool used for hoeing (Page 113).

Kasoli—A small *Kasola* (Page 113).

Katha—A local variety of sugarcane (Page 308).

Katki—Pertaining to *Katak*, a month in Indian Calendar, comprising ½ October and ½ November.

Kera—A method of sowing in which seed is dropped by a separate man behind the plough.

Khaddar—Coarse cloth manufactured from home spun yarn.

Khadir—Low-lying tract near a river.

Khal—A water channel.

Khanchis—A tank used for manufacturing white sugar on a small scale. (Page 320).

Khandsari—Manufacturing of white sugar on a small scale (Page 320), by open Pan system.

Khapra—Larva of *Trogoderma* khapra (Page 236).

Kharaba—Remission of land revenue and water rates.

Kharas—A bullock-worked grinding mill.

Khar buti—See *lani*.

Kharif—Monsoon or summer crop.

Khatti—An underground or above ground or partially above ground store for grains.

Kheera—Cucumber (Page 377).

Khichri—A pudding prepared by boiling together rice and pulses, in water and seasoning with salt and spices.

Khudda—A poultry house.

Khudrawi—A variety of dates.

Khumb—Mushroom (Page 497).

Khumb—A weed (Page 213).

Khurpa—Also *ramba*: hand-hoe (Page 113).

Kiara—A compartment of a field for irrigation purposes.

Kiari—A smaller *kiara*.

Kikar—*Acacia arabica*.

Killa—1/25th of a square or rectangle. In Lower Chenab Canal Colony=1.1 acres. In Lower Bari Doab Canal Colony= 1 acre.

Killi—Toggle or wooden pin (Page 111).

Kodra—*Paspalum scrobiculatum* (Page 284.)

Kohlu—Bullock-mill for crushing oilseeds.

Kor (watering)—First watering after sowing.

Kotha—A large room used for storing wheat or other grains.

Kothi—A rectangular mud-bin for storing grain.

Kudali—A hand tool used for harvesting cottonsticks, etc.

Kulahara—A large-sized axe.

Kulhari—An axe (Page 113).

Kup—Also called *musal*, a conical stack of stored bhusa generally thatched with straw.

Kur—*Share of the desi plough* (Page 73).

Kurrum mash—*Mash* grown in Kurrum valley N.-W.F.P. (Page 291).

Kurund—A weed (Page 219).

Kusum—Raise it.

Kusumbha—Safflower (400).

Kutta Ghas—*Cenchrus echinatus*

Laddu—Gur in the form of small balls weighing about one or two chhataks.

Lakh—One hundred thousand.

Lal Basmati—The same as *Mushkan* rice.

Lal Dudhi—A weed (Page 212).

Lal Kasarwali—Bearded red-awned wheat.

Lalri—A local type of sugarcane (Page 308).

Lambardar—A village headman.

Lanb—A weed (Page 214).

Langra—A variety of mangoes.

Lani—*Atriplex conforiiolia* (Page 43).

Lappas—A strip of iron o wood fixed behind the *sohaga* to help in breaking clod .

Lassan—Garlic (Page 369).

Lassi—Butter milk.

Lath—Shaft.

Leeping—Rubbing over with cow dung : cotton seed is thus treated before sowing.

Leh—A weed (Page 217).

Lehli—A weed (Page 217).

Lobia—A type of beans.

Lohri— A Hindu festival in the month of January.

Lunak—A weed (Page 214).

Lusan—Lucern or alfalfa (Page 469).

Madhana—A weed (Page 214).

Mahl—Bucket chain of a persian wheal (Page 142).

Mahun—The Indian honey bee (page 536).

Maida—A fraction of wheat flour.

Maina—A weed (Page 218).

Maini—A weed (Page 218).

Maira—Sandy soil.

Makai—Maize (Page 266).

Makchari—Teosinte (Page 471).

Makhmali Sem—Velvet beans (Page 473).

Makoh—A type of weed (Page 207).

Malka—Bold red variety of lentil grown mostly in D. G. Khan district.

Malta—A type of orange.

Mandi—A market.

Mandhal—*Eleusina coracana* (Page 281).

Mandli—Loose stacks into which wheat crop is stacked after harvesting (Page 231).

Marla—1/20th of a kanal or 1/160 of an acre.

Marunda—A preparation in which boiled, husked and roasted rice is mixed with *gur* syrup, and rolled into balls.

Mash—*Phaseolus radiatus* (Page 290).

Mash dal—Split *mash* grains.

Masri—Small seeded type of lentil (Page 292).

Massar—*Lens esculenta* (Page 292).

Mat—A large earthen pitcher.

Matar—*Pisum sativum* (Page 363).

Maund—82 2/7 lbs. or 40 seers.

Mehndi—Myrtle or henna (Page 495).

Mehr—Three or four bullocks tied abreast for threshing crops by trampling.

Metha } Fenugreek. A fodder crop
Methra } (Page 462).

Minja —A type of brown sugar more crystalline than shakkar.

Mirch Surkh—Chillies (Page 372).

Missa—Mixed.

Missa-bhusa—Gram bhusa.

Missi roti—Chapati made from wheat and gram flour mixture.

Mitha—A type of citrus fruit.

Mohla—Pestle.

Mote—See *charsa*.

Moth—*Phaseolus aconitifolius* (Page 291).

Motha—A weed (Page 211).

Muharas—Maize stacks (Page 270).

Mukaddam—A subordinate officer in the Agricultural Department.

Muli—Radish (Page 366).

Munaras—The same as *muharas*.

Munah (plough)—A form of native plough in use in the Punjab (Page 72).

Mung—*Phaseolus mungo* (Page 288).

Mungphali—Groundnut (Page 401).

Munj—Fibre derived from the leaf-sheath of top node of *sarkanda*.

Murabba—A square of land measuring 25 *killas* or acres as the case may be.

Musal—See *kup*.

Mushkan—A fine variety of rice.

Mut—A large earthen pitcher, also written as a *mat*.

Muthia—A part of a yoke (Page 111).

Muqaddam—The same as Mukaddam.

Nag hal—A type of indigenous plough in which the share consists of a long iron bar and the *chow* is protected on sides by strips of iron.

Nali—A pipe. See also *por*.

Neem—*Melia azadirachta*.

Nehri—Canal irrigated.

Nil—*Indigofera tinctoria*, Indigo (Page 488).

Nili Bar—A tract in the Montgomery and Multan districts.

Okru—Plough running on its tip (Page 74).

Okra—Lady's Finger (Page 374).

Oomras—Commercial name of a central Indian Cotton of medium staple.

Oont Katara—A weed (Page 214).

Pahar—A division of time into which a day is divided; equal to 3 hours. Turn of water of 3 hours.

Pahaura—See *Phaura*.

Pakauras—A fried preparation from gram flour.

Pakka artya—A commission agent purchasing produce from the local market on behalf of outside concerns, or helping in such purchases.

Palak—*Beta bengalensis* (Page 380).

Palla—A cylindrical stack or stored *bhusa* thatched with mud.

Palli—Circular or conical structures made of *Sarkanda* or matting of plaited date palm leaves for storing grain.

Panjali—A yoke (Page 111).

Panjdantta—A horse-hoe or cultivator with 5 tines (Page 81).

Pansari—A druggist.

Pansera—A form of gur in *bhelis* of five seers each (Page 319).

Papri—The same as *karand*.

Pat—Sugarcane juice boiled at a time for preparing *gur*.

Patwari—Village revenue or irrigation subordinate, a village accountant or registrar.

Pesi—Small akes of *ur* (Page 318).

Petha—Ash gourd (Page 375).

Phak—Husk separated from rice at the time of husking.

Phali—See *Phalla*.

Phala—Share of a plough (Page 72

Phalai—*Acacia modesta*.

Phalli—A hurdle dragged by bullocks in wheat-threshing.

Phalsa—*Grewia asiatica* (Page 339).

Phana—A wedge in a plough (Page 73).

Phat—A part of a yoke (Page 111).

Phaura—A hand tool used for collecting dung or grains on the threshing floor (Page 113).

Phauri—A similar hand tool used for levelling beds at the time of *rauni* and making water muddy for sowing *senji*.

Phulan ghas—A weed (Page 214).

Phulian—A preparation in which paddy is soaked in hot water, subsequently put in bags for a night, next day while still wet roasted till the seeds swell up, and then husked.

Phul gobhi—Cauliflower (Page 360).

Piaz—Onion (Page 367).

Piazi—A weed (Page 215).

Pilchhi datri—A sickle without teeth used for stripping sugarcane (Page 114).

Pipal—*Ficus religiosa*.

Podina—Mint (381).

Pohli—A weed (Page 216).

Ponda—A thick variety of sugarcane used for chewing mainly.

Poni—A kind of sieve provided with a handle used for removing scum from sugarcane juice when boiling.

Por—Also called *nali*. A seed tube with funnel-shaped mouth attached behind the plough for sowing.

Pora—Sowing with the *por*. In *pora* method of sowing the same man controls the plough and drops the seed.

Por hal—Single row cotton drill.

Post—Poppy (Page 499).

Pucca—Masonary : Metalled : ripe.

Puna—*Ehretia acuminata*.

Punjabi—Pertaining to the Punjab.

Pura—Damp wind from the East.

Purdah—Seclusion from public view.

Rab—Partly boiled and concentrated cane juice fit for making sugar (Page 320).

Rabi—Winter crops.

Rabri—A preparation made from *bajri* flour and *lassi* (butter milk). (Page 280).

Ragi—*Eleusina Coracana* (Page 281).

Rahal—Divisions of a field for ploughing with an indigenous plough (Page 73).

Rahat—See *rehat*.

Rajbaha—Canal distributory.

Rakkar—Soils with high alkalinity, but salt content not necessarily high.

Ramba—See *Khurpa*.

Ramio kos—Common *charsa*.

Rauni—Watering applied shortly before sowing.

Rawa—A grade of wheat flour.

Rawan—Cowpeas (Page 472).

Reh—See *kallar*.

Rehat—Persian-wheel (Page 142).

Rewari—A weed (Page 218).

Rewaris—A sweet prepared from sesamum seeds and sugar lumps.

Richni—A weed (Page 212).

Roris—Small lumps of *gur* weighing about one to two chhataks (Page 318).

Sabaz Gobhi—Broccoli (Page 363).

Sag—Pot-herb.

Sailab, *Sailaba*, *Sailabi*—Land subject to periodical or annual floods.

Sajji—Ashes of *lani* containing high percentage of sodium salts, used for washing clothes (Page 43).

Salad—Lettuce (Page 381).

Salahri—Celery (Page 382).

Sanga—Wooden fork: a hand tool (Page 114).

Sangtra—A kind of citrus fruit.

Sanha—Front part of the beam of a *hal* with holes (Pages 72, 73).

Sankukra—Deccan hemp (Page 454).

Sarson—Indian colza (Page 395).

Sathra—A coarse variety of rice.

Sattu—A preparation from barley for which slightly under-ripe ears of barley are plucked and grains are then roasted and ground.

Seer—1/40th of a maund, approximately=2 lbs.

Sela (Rice)—Parboiled rice (Page 262).

Sem—Water-logging.

Senji—Indian clover (Page 461).

Sewyan—A kind of macaroni.

Shaftal—Persian Clover (Page 468).

Shahtra—A weed (Page 219).

Shain—*Pleatranthus rugosus*.

Shakkar—Raw sugar in powdery form.

Shalgham—Turnips (Page 364).

Shamlat—Village common land.

Sharbati—Amber.

Shaqar qandi—Sweet potato (Page 379).

Shisham—*Dalbergia sisoo*.

Sida—A weed (Page 207).

Sohaga—Wooden beam worked by 2 pairs of bullocks, used for breaking clods and covering seed (Page 87).

Sohagi—Smaller *sohaga* worked by 1 pair of bullocks.

Sohaging—Running a *sohaga*.

Sokru—A plough running too shallow (Page 74).

Sanchal—*Malva parviflora*; a weed.

Sone—A coarse variety of rice.

Sone chiri—Bee-eater bird (Page 538).

Sufaid—White.

Sufaida—A variety of rice belonging to *palmal* group.

Suji—A fraction of wheat flour.

Sundi—Larval stage of certain insects.

Sundio kos—Self delivery *charsa* (Page 150).

Suretha—A local type of sugarcane (Page 308).

Susri—Any small beetle attacking stored grain, *e.g.*, *Calendra oryzae* and *Rhizopertha dominica*.

Swank—*Panicum colonum* (Page 283).

Tahsil—A sub-division of a district, charge of Tahsildar.

Tahsildar—An executive officer in-charge of a Tahsil.

Takavi—Loan granted by Government to land-owner for agricultural purposes.

Talla—A weed (Page 209).

Tamatar—Tomatoes (Page 370).

Tambaku—Tobacco (Page 479).

Tandla—A weed (Page 212).

Tangar—A sheet usually of hesian cloth meant for carrying bhusa.

Taramira—Rocket (Page 396).

Tarphali—See *Tirphali*.

Tehsil—See *Tahsil*.

Tehsildar—See *Tahsildar*.

Tela—A small sucking insect, *e. g.*, aphis.

Thapi—A hand tool for stirring a *pat* in a *gand*.

Theka—A bin made of sacking for storing grain.

Thur—Land where salt content is high but the process of alkalisation has not proceeded very far.

Tidda—A pest of cotton.

Til—Sesamum (Page 397).

Tinda—*Citrullus Vulgaris Var, Fistulosus*.

Tinseri—A *bheli* of gur weighing 3 seers (Page 318).

Tirak—A disease of cotton in which the leaves turn reddish and the bolls fail to open out.

Tirpal—Tarpaulin.

Tirphali—A three-tined hoe (Page 85).

Toka—Hand chopper.

Tokra—A basket.

Toria—Indian rape (Page 392).

Trangli—A 5 to 7 pronged iron fork

with a wooden handle (Page 114).

Tun —*Cadrela tuna.*

Turi—Wheat *bhusa.*

Ukhli—Mortar.

Ussar—See *kallar.*

Vanaspati ghee—See *banaspati ghee.*

Vari—Turn for irrigation. Also written as *Wari.*

Vattar—Right condition of land for ploughing after rain or irrigation.

Vehri—A weed (Page 217).

Wadanak—Macaroni wheat (*Triticum durum*).

Wadh—Stubble.

Wadh Watter—A crop sown in the moisture left by the last irrigation to the previous crop, *e.g.*, gram sown after *chari* or rice.

Wahn (Watering)—Watering applied to a field to enable it to be ploughed.

Wan—*Salvadora Oleoides.* A tree found in arid tracts.

Wari—Turn of irrigation. Also written as *vari.*

Wat—Also *bund,* irrigation ridges.

Wattar—See *vattar.*

Wazir—A minister.

Zaid-kharif—Crops of the season midway between *kharif* and *rabi,* autumn crops, *e.g.*, *toria.*

Zaid-rabi—Crops of the season midway between *rabi* and *kharif;* spring crops, *e.g.*, melons.

Zail—One of the sub-division of a tehsil comprising of a number of villages.

Zaildar—A non-official helping in the work of running a zail.

Zemindar—A farmer, may be a tenant or an owner.

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