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DRY FARMING

DEVELOPMENTAL RESEARCH IN THE BLACK SOILS
OF BELLARY DISTRICT
(MADRAS STATE)

BY

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AND

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CONTENTS

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INTRODUCTION

DRY farming is a system of soil and crop management in regions of low and uncertain rainfall. Such regions are widely distributed in the world. In India, these regions occupy longitudinally the central core of the country, namely the Rohtak area of the Punjab, Madhya Bharat and the Bombay-Hyderabad-Madras-Deccan area. With a view to improving the agriculture of this tract, research work was initiated by the Indian Council of Agricultural Research in 1935, at four regional centres, Rohtak in the Punjab, Sholapur in Bombay, Raichur in Hyderabad and Hagari in Madras, with the co-operation of the respective State administrations.

Each sub-area has its own peculiar rainfall, soil conditions and cropping practices. The varieties of crops grown are also different. From the practical point of view, each sub-tract has its own peculiar problems different from the others so that, though co-ordination on fundamental work was effected on a common basis, each station had to solve its own local problems. The subject matter of this publication is the developmental work that was undertaken during 1943 to 1947 in cultivators' fields, applying the results of research completed at the Hagari Station during the previous period.

In order to understand the problems that are involved in this tract, a brief account of the peculiarities of the rainfall, the soils, the crops and the general cultivation adopted in this tract of the Bellary district in which Hagari is situated, is given here.

RAINFALL

The annual rainfall here is about 20 in. varying from 11 in. to 23 in. The hot weather contributes about three or four inches of rain during which period preparatory cultivation of the land is attended to.

The south-west monsoon (June, July, August) contributes about six or seven inches. The rainfall during this period is too weak for the successful cultivation of *mugari* or *kharif* crops in this area. The main rainy period is September to November during which normally 10 or 12 in. of rain are received, generally in torrents. This rain is most important for the tract, during which the main *hingari* or *rabi* crops grow A serious deficiency of rain during this period spells famine. The failure of rain is not uncommon in this tract and it occurs once in about seven years. In addition to such total failures, partial failures are very common and they occur two or three times in a period of five years. Thus it is apparent that in this tract the rainfall is insufficient and uncertain. The problem is how best the rain water could be held on these black soils and utilised to support a crop.

Soils

The soils are heavy black cotton soils varying in depth from 18 in. to over 48 in The soils are slow to absorb rain water much of which is lost as run off. This also causes loss of good soil by erosion. The soils are heavy for working and have a large clay content. They are low in organic matter and nitrogen. There are nearly 6,00,000 acres of this kind of soil in this district. The problems to be tackled in these soils are, therefore,

(i) To increase the ability of these soils to take in more rain water,

(ii) To reduce the run off rain water and consequent soil erosion, and,

(iii) To increase the fertility of the soils to produce better crops.

Crops

The most common crops grown in this tract are *jowar* (sorghum, *jola* or *cholam*) and cotton which are always grown in rotation. Another cereal *navane*, (setaria or *kangune*, or *tenai*) is also very commonly grown as a mixed crop with cotton in the proportion of one or two lines of setaria to one line of cotton. To a lesser extent it is also grown as a pure crop by itself. The two cereals are the staple food of the population and the straw is the main stay of the cattle. The cotton is known under the trade name 'Westerns' and is a source of cash for the cultivators. It is sown in September. The average yields per acre of the crops are low, in fact they are the lowest in the State. The *jowar* is the white grained sorghum. It is sown in October and gives an acre yield of about 300 lb. of grain and 800 lb. of dry straw. The setaria crop gives about 250 lb. of grain and 500 lb. of straw. The cotton crop gives about 250 lb. of *kapas* per acre. The problem in crop improvement is the evolution of drought resistant and high yielding strains of these crops.

Economic conditions

The cultivators are very poor and their power of investment for land improvement is low. The average size of a holding is about 10 acres and the tract is thinly populated. When suggesting dry farming improvements for adoption by the cultivators, these factors have to be remembered.

Local cultivation

The cultivation practices adopted in this tract are very simple, efficient and peculiar. There are only two simple implements which are most commonly used by all cultivators. They are (i) the *guntaka* or the blade harrow and (ii) the *gorru* or the seed drill. The *guntaka* is a wooden beam harrow with an iron blade which is about three feet long. This is drawn by one pair of bullocks. It has a draft of about ¾ cwt. and cuts the ground to a depth of 2 to 2½ inches. It is used for preparatory cultivation to bring the land to tilth. Starting from the summer rains in April-May, the implement is worked after every subsequent rain, and friable soil, free of weeds to a depth of two to three inches, is obtained by working it three to four times till the sowing period in September, October. The seed drill or *gorru* is another wooden implement with six tynes, the tynes being 13½ in. apart. The tynes are shod with iron share points. The same drill is used for sowing both cotton and *jowar*. *Jowar* is sown through all the six tynes, the lines being 13½ in. apart. Cotton is sown by the same drill, the lines being 27 in. apart, by blocking the alternate tynes. This is a very cheap and efficient implement with a draft of about 1½ cwt. and a skilled farmer can sow in perfectly straight lines. This implement is followed by the *guntaka* for covering the seeds. In addition to these two implements, a set of intercultivating implements is used to cultivate the inter-space between the lines of crops. These are just like the *guntaka* but only the size is much smaller, being practically baby *guntakas*. They are about 10 to 11 in. wide and fit the inter-space between the rows. Four or five of them form one set and each of them is tied independently to the yoke in its proper place. This implement is called the *danthi*. All these implements are suitable for shallow cultivation which is typical of this tract and they cover large areas The *guntaka* covers about three to four acres per day. The seed drill covers about five acres per day. A set of four *danthies* cover about four acres per day. A farmer having about 30 acres of land will have two *guntakas*, one seed drill and a set of *danthies*. A seed drill can manage one hundred acres in the sowing season. It is a common practice for farmers both small and big to co-operate during the time of sowing and complete sowing of all the land in their village by their combined efforts. Some farmers have only a single bullock each and some only one *guntaka*, and another may have only a seed drill. They all join together, make up a complete equipment tackle and finish the job. This is a very pleasing sight in the villages of this tract during the sowing time.

In the deep black cotton soils of this tract, the type of common cultivation is shallow and extensive. Deep cultivation with a heavy plough employing five or six pairs of animals and ploughing deep and raising big clods is resorted to only in such fields as have become foul by deep rooted perennial weeds like *hariali* (*Cynodon*). Good cultivators do not allow this weed to come up and only neglected lands and fields which are subject to washes become foul with this weed. Even in this case, a number of farmers often co-operate with one another, pool their resources of bullocks, plough, etc. and complete their job. Deep ploughing is given early in the summer, so that the weed is exposed and gets killed during the heat of the summer.

DRY FARMING RESEARCH AT HAGARI

WITH the background as discussed previously, dry farming research for Madras State was initiated at the Agricultural Research Station, Hagari, in 1934-35, with financial help from the Indian Council of Agricultural Research on a 50 : 50 basis with a view to making a scientific study of the problems involved and to suggest suitable solutions for the same. This is the first phase of research which was conducted at the Research Station in small experimental plots. The research phase continued till 1942-43. This phase was naturally somewhat prolonged owing to the occurence of some bad years during this period and to confirm the results of experiments by sufficient repetitions through years. The developmental phase was the next phase of this research during which period, the results that could be put across to the cultivators were tried on a large scale in cultivators' holdings with a view to obtaining practical experience with these suggested improvements. The developmental phase lasted from 1942-43 to 1947-48 which is described in the next chapter. In this chapter the findings of the first phase of work, viz. the experimental phase on the research station, are briefly given.

During this phase of work (Dry Farming Research at Hagari Station, 1934 to 1942), investigations were made on the fundamental aspects of the problem. The studies included (a) rainfall and seasons, (b) soil studies, (c) crop studies, and (d) agronomic investigations. A detailed report of the investigations during this phase of the work at Hagari has already been published as a monograph by Kanitkar (1944). This phase of the work has been briefly mentioned here in general terms to serve as a background for the developmental work in the next chapter, which is the main subject of this bulletin.

Rainfall

Kanitkar (1944)* has given a detailed account of the meteorological conditions in the dry farming areas of India.

The rainfall during the 10-year period, 1934 to 1943 (monthwise), at Hagari is given in Table I.

Table I

Rainfall at Hagari

Year	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943
January	-nil-	0.2	-nil-	-nil-	nil-	-nil-	-nil-	-nil-	-nil-	0.37
February	-nil-	-nil-	0.09	0.48	0.37	-nil-	-nil-	0.23	0.29	-nil-
March	-nil-	-nil-	0.73	0.67	0.41	-nil-	-nil-	-nil-	-nil-	0.15
April	1.81	1.41	0.21	2.66	0.40	0.35	2.14	0.84	1.80	1.46
May	1.19	0.21	1.88	0.58	0.64	0.26	7.32	1.46	0.35	4.12
June	1.04	5.03	1.38	0.23	0.64	1.97	1.31	0.91	5.24	0.98
July	1.43	4.21	0.79	1.05	1.30	2.14	0.99	0.52	0.23	0.49
August	4.59	3.57	1.01	0.62	9.28	5.82	1.78	1.98	1.43	0.90
September	0.16	3.06	7.50	7.14	7.72	2.77	2.41	6.53	0.87	5.75
October	2.28	4.08	3.27	2.35	0.11	7.62	4.99	2.37	0.31	1.83
November	1.62	0.29	6.20	0.05	-nil-	0.37	0.91	-nil-	1.06	2.30
December	-nil-	-nil-	-nil-	-nil-	-nil-	-nil-	0.19	1.36	0.01	-nil-
Total (annual)	12.12	21.88	23.6	15.73	22.87	21.30	22.04	16.23	11.59	18.35

This wide variation in the total rainfall at Hagari through the 10-year period is also graphically represented (Fig. I). The crucial months during which the rainfall occurs are May to October. The variation of rainfall during these months is

***Scientific Monograph No. 15, Imperial Council of Agricultural Research, Dry Farming in India by N. V. Kanitkar, Chief Investigator, Bombay Dry Farming Research Scheme, 1944**

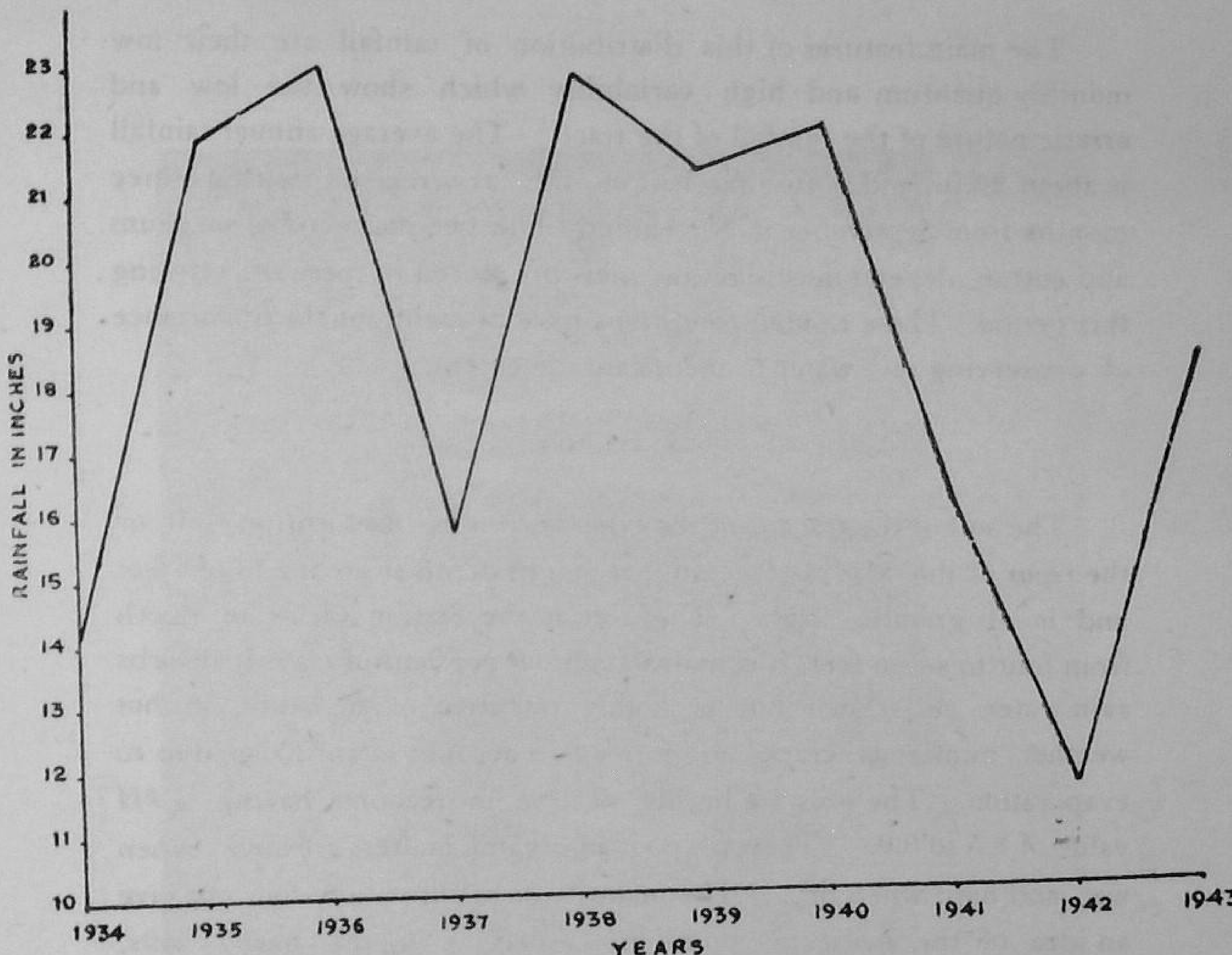


Fig. I. Graph showing variability of monthly and annual rainfall

also very wide. The variability of monthly and annual rainfall with their standard errors and co-efficient of variability are presented in Table II.

TABLE II

Variability of the monthly and annual rainfall at Hagari
(average of 19 years)
(After Kanitkar)

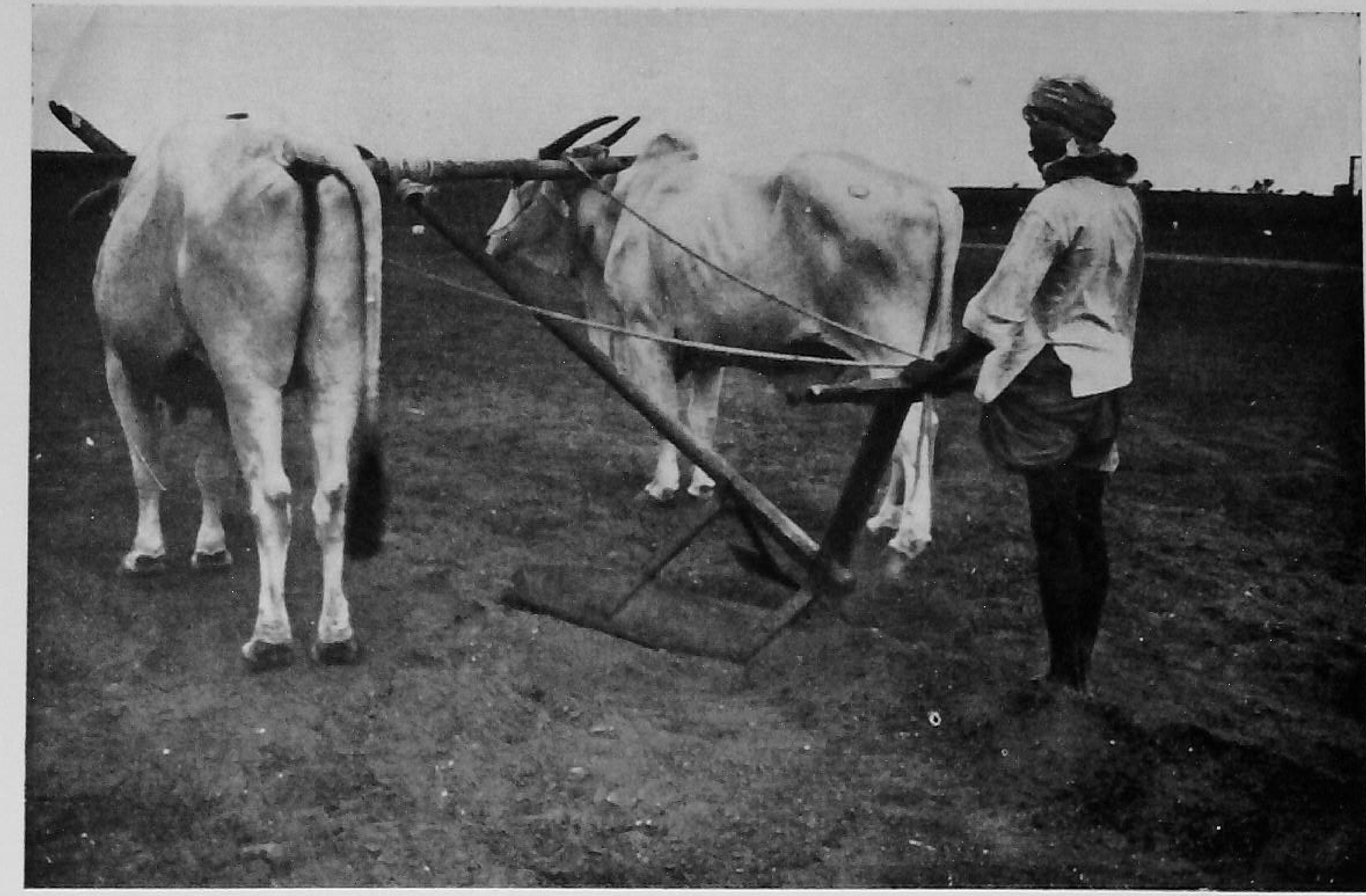
	May	June	July	August	September	October	Total
Rainfall in inches	1.43	1.27	1.50	2.79	4.33	4.75	19.46
Standard error		1.01	1.26	3.33	2.32	3.44	6.31
Variability per cent		79	84	119	53	72	32

The main features of this distribution of rainfall are their low monthly quantum and high variability which show the low and erratic nature of the rainfall of the tract. The average annual rainfall is about 20 in. and more than half of this is received within three months from September to November. The two main crops, sorghum and cotton; depend mostly on the moisture stored in these soils during this period. These rainfall conditions have brought out the importance of conserving rain water to the maximum extent.

Soil studies

The soil of the tract is of the type known as black cotton soil or the *regur* of the Madras Deccan, varying in depth from one to ten feet and is of granitic origin. The soil at the Station varies in depth from four to seven feet. It contains about 50 per cent of clay. It absorbs rain water very slowly but is highly retentive of moisture, in hot weather numerous cracks are formed on account of shrinkage due to evaporation. The soils are highly alkaline in reaction having a *pH* value of 8.5 to 9.0. They are poor in organic matter, are sticky when wet and hard when dry. The quantity of precipitation does not give an idea of the moisture conditions especially in the heavy soils, where a large proportion of rainfall is lost by surface flow owing to the fact that the soil is very slow to absorb rain water. Due to the presence of a high proportion of colloidal clay, the soil swells enormously when wet and the pore spaces in the soil get clogged; percolation of rain water to the lower layers of the soil is reduced, resulting in run off. Experiments on surface run off conducted at Hagari have shown that even at a gentle gradient of 1 in 80 as much as 33 to 48 per cent of the rainfall was lost by the surface flow, during the three years 1937-39. Along with the loss of the rain water, there is also loss of soil through erosion. Every inch of run off water carried away about 1.5 tons of silt per acre. Intense storms and heavy rains cause greater run off and soil loss than gentle rains. The amount of soil loss through erosion was also dependent on the slope of the land. The silt that is lost through erosion is richer than the soil of the field from which it is removed. Any method which reduces the velocity of

PLATE I



Bund-former

the run off water, reduces the amount of run off. Methods of culture have to be devised which would enable either a quicker rate of penetration of rain water into the top soil or a longer time should be allowed for the rain water to stand in the field giving a greater chance for it to be absorbed by the soil. Bunding allows the rain water to stand on the field for a longer time, thus facilitating its absorption by the soil. In cultural operations like ploughing or the addition of organic matter, the top soil is brought into a good physical condition for absorption of rain water.

It was found during the course of these studies that the moisture content in the second foot-layer has a decisive effect on the yield of crops which are also influenced by the moisture content of the soil at the sowing time to a large extent. Percolation of rain water to the lower layers of the soil was found to be very slow due to the heavy nature of the soil and there is consequently a lag in the absorption of moisture by the lower layers. Once the moisture content of any layer reaches about 25 per cent, the percolation to the lower layers is improved, due to the continuity of moisture films established within the pure spaces of the soil. The black soils of Hagari shrink heavily on drying owing to the high colloidal status—the shrinkage coefficient being about 65 per cent by volume. Owing to the high shrinkage coefficient, numerous cracks are formed in the field. According to Dr A. Subba Rao, Soil Physicist, conservation of moisture reduces the shrinkage and consequently the amount of cracking during the period of crop growth.

Crop studies

The main food crops of the station are sorghum (*jowar* or *jonna* or *cholam*) and setaria (*kangoone* or *korra* or *tenai*). Breeding work was undertaken with a view to evolve high yielding and drought resistant types of these two millets for cultivation in this area. In the case of Sorghum, the work was confined to the testing of short duration strains from the Bombay State. It was found that M. 47-3 (*Maldandi* of Bombay) was suitable to the conditions at Hagari. It had a duration of 120 days as compared to the Hagari type H. 1 with a duration of

135 days. When the rainfall was low, M. 47-3 was better than H. 1 in grain yields. The defect of M. 47-3 however was that its height was shorter and the yield of straw lower.

In setaria, pure line selection has resulted in the evolution of two high yielding selections K. 23 and K. 68 which were later given station numbers of H. 1 and H. 2.

The root systems of various crops were studied in greater detail. The roots of setaria were thinner, finer and more profusely branched. In sorghum the short duration Bombay types were found to put forth a larger number of roots in the early stages as compared to the local types. Owing to this development of a quicker and more efficient root system, the Bombay sorghums have been able to withstand drought better than the local varieties. Soil conservation methods like bunding, fallowing, manuring, etc. had the effect of increasing the root development of plants. Soil erosion is a serious problem in these soils and a study was made with regard to the effect of plant cover to check soil erosion. Cotton afforded very little protection to the soil. The ratio between the time taken to erode a definite volume of soil under a particular type of plant cover to the time taken to erode a similar quantity of bare soil without any plant cover has been taken as a measure of the relative anti-erosive efficiency of that particular crop cover. The setaria crop had an anti-erosive ratio of 4 at the age of three months. Groundnut was more efficient with an anti-erosive ratio of 4.6. Sorghum, being the crop grown at the end of rainy season, does not afford any protection.

Agronomic investigations

The soil of this tract is the heavy black cotton soil which does not absorb rain water freely. Much of the rain water is thus lost as run off and along with it the fine particles of soil are also lost. The amount of run off and soil erosion depend on the slope of the land and also the intensity of rainfall. This area receives an average annual rainfall of about 20 in. which is the lowest in the whole of this State. The distribution of rainfall is a very important factor in the success of growing crops. Very often the distribution is unfavourable. The average yields of the chief crops, setaria, sorghum and cotton are all very low being about 300 lb., 350 lb. and 250 lb. per acre respectively. These are also the lowest yields for these crops in this State. After deducting the cost of cultivation, a very small margin of profit is left to the cultivator. With these low values, the economic backing of the cultivator is also poor. The cultivator will not be able to adopt any costly methods of improvement. Therefore, it has been the chief aim of agronomic research at this Station to try and evolve only such improved agricuitutal practices as are within the means of the average cultivator.

Among the various field experiments the object of which was to devise ways and means of making the black soils of this tract absorb more rain water and lessen the wasteful run off by suitable agronomic practices, it was found that bunding with a bund-forming implement was the most successful. It was also the cheapest method of increasing crop yields. The bunds are about 7 in. high and are formed by an implement known as 'Bund-former' (Plate I facing page 8) which is drawn by a pair of animals. Bunds and cross bunds can easily be formed dividing the fields into a number of small bunded compartments of 5 to 10 cents in area. With the help of this implement, 8 to 10 acres can be worked in a day. The cost of this kind of bunding in those days came to about a few annas per acre. These are only temporary bunds and crops could be sown in the fields during which operation the bunds get erased. By the time the sowing takes place, the bunds would have performed their function of catching the rain water in the bunded compartments upto the time of sowing. The benefit from this kind of bunding was greatest in years of low rainfall. The experimental stage with this kind of bunding on the Hagari Station lasted for eight years. It was found that on an average the bunded plots gave Rs. 3 as. 12 more net profit per acre per annum than the plots not bunded. Soil moisture determinations have shown that the plots so bunded have the capacity of absorbing more rain water than plots which have not been thus bunded. The bunded plots have absorbed 49 per cent of the total rainfall received in 1939-40 while the plots which have not been bunded absorbed only 34 per cent of the total rainfall. The increased moisture in bunded plots is reflected in increased yields.

The scooping trials revealed that they were not better than bunding in effect but were more costly. In the spacing experiments with sorghum and cotton, it was found that a spacing of 18 in. for sorghum and 36 in. for cotton was more beneficial than the local spacings of 13½ in. and 27 in. respectively.

In the experiments on the intercultures of sorghum and cotton, it was found that the main benefit derived from intercultivation was the removal of weed competition. Hand weeding is costly and the cheapest way of removing weeds is by intercultivation with the help of bullocks. Intercultivation definitely closes down the small cracks that are formed in the soil early in the season in the months of December-January and helps in the prevention of loss of moisture from the soil. The number of intercultures depended on the frequencies of rain and consequent weed growth.

In the fallowing experiment, it was found that fallowing was not a profitable practice in this tract. From the manurial experiments, it was found that a dose of 6,000 lb. of cattle manure applied per acre once in three years to a field was the optimum dose. Cattle manure is scarce in these areas and it is of no use suggesting higher doses. A combination of manuring and bunding has given the best results.

DRY FARMING DEVELOPMENTAL WORK

THE practical results thus obtained were put in the next phase to large scale trials in cultivators fields roundabout the farm over an area of about 500 acres, to obtain an idea about their suitability for their adoption by the cultivators. This developmental phase of work commenced in 1943-44 and continued till 1947-48, for a period of five years. The cultivators were willing to try these improvements in their own fields without additional cost to the Government. They supplied all the labour necessary at their own cost for conducting these operations while the Government helped them by providing the necessary implements for putting up of bunds. A new item of work which was undertaken during this period was the trials with permanent field embankments over an area of about 70 acres in the cultivators' fields. The bunds were put up at the cost of the Government and observations on their behaviour were recorded by the developmental staff.

The improved dry farming practices that were tried on a large scale in the cultivators' fields are as follows :

1. Trials with bund-former bunding
2. Wide spacing of crops
3. Improved strains of millets
4. Manuring the fields
5. Contour cultivation
6. Permanent field embankments

The experience gained by the large scale application of the above-noted improved dry farming practices, together with the recommendations for their proper adoption by the cultivators, is described in this chapter.

Trials with bund-former bunding

This was tried over a total area of about 1,300 acres on cultivators' fields, spread over five seasons, under close observation. It was tried on the common crops grown in this area, viz. setaria, cotton and sorghum. The results obtained from this work were consistent. A steady, though small, increase in yield was recorded each year, the increase varying from 11 to 18 per cent over non-bunded areas. The cost of this kind of bunding is about 10 to 12 annas per acre, one pair of animals working the implement over 10 acres a day. The cost of this is low and is within the reach of all cultivators. The value of the increased produce is about six rupees per acre at the rates prevailing at the time. In terms of additional produce, it means an average increased yield of about 50 lb. of grain per acre. The yields obtained by bunding compared with 'no bunding' are given in Table III.

TABLE III

Effect of bund-former bunding on sorghum H. 1 (Hagari)

(per acre yields in pounds)

Year	Rainfall (January to December)	Bunded		Not bunded		Increase due to bunding	
		Grain	Straw	Grain	Straw	Grain	Straw
1944-45	23.43 in.	409	1,425	373	1,374	36	51
1945-46	15.56 in.	152	393	130	344	22	49
1946-47	22.38 in.	131	1,142	112	923	19	219
1947-48	17.68 in.	490	780	391	563	99	217
Average per year		295	935	251	801	44	134
			Percentage of increase			17.1	16.7

TABLE IV

Economics of the operation

	Value of increase Rs.	as.	Cost of bunding Rs.	as.	Net value of increase due to bunding Rs.	as.
Increased yield of grain 44 lb. per acre	4	6				
Increased yield of straw 134 lb. per acre	2	11				
Total	7	1	0	12	6	5

N. B. (1) Produce valued at sorghum grain 10 lb. per rupee and straw at 50 lb. per rupee.

(2) In 1946-47 though sufficient rains fell, the yields were very poor owing to diseases and pests as there were heavy untimely rains.

Bund-former bunding consists of putting up of small bunds six to seven inches high with about 18 in. base by means of an implement called the 'Bund-former' which is drawn by a pair of bullocks along and across the field. It thus forms bunded compartments of about 100 ft. x 100 ft. The intersections of bunds are closed by hand. These bunded compartments help to trap the rain water and to make it stand on the land to a longer extent, than it would otherwise have stood if the compartments were not put up. The rain water is thus forced into the ground to a certain extent without being allowed to run away from the land. The additional amount of moisture that is now forced into the land helps in raising a better crop. The implement has to be worked each year as the final operation in preliminary cultivation. The implement is a simple one and consists of two collecting blades. It is manufactured in two sizes, the bigger implement has a blade five feet long and the smaller, three feet six inches long. The bunding is done early in the season in the months of June-July so that the bunded compartments may catch sufficient rain water before the sowing time of the crops. These bunds, being small and temporary, naturally breach when there are heavy rains. But by the time they breach they would have done their job, i. e. they would have held sufficient water to obtain the necessary pressure for breaching. If the bunds were not there, the water would not have stood on the land at all. Careful cultivators close up these breaches and will try to catch the next rain also. At the time of sowing in September-October the crops are sown in the field when the remnants of the bunds get automatically obliterated.

The improvement in yield effected by working this implement is, however, not phenomenal and, therefore, a great demand for the same may not be readily expected. With the background of the adverse circumstances prevailing in this tract, no phenomenal improvement could be effected in this area except by providing irrigation water.

So, to popularise the use of this implement, it will be necessary to make them available in sufficient numbers in important villages and to continue the demonstration of the same by the Agricultural Department, which is being done. These bunds are more useful in lands having a gentle slope 0.5 per cent or less. In higher slopes they are apt to give way more frequently and are less useful. In such cases permanent field embankments are recommended.

Wide spacing of crops

The local spacing in the Hagari tract between the lines of cotton is 27 in. and between the lines of sorghum, 13½ in. It was found that a slightly wider spacing of 36 in. for cotton and 18 in. for sorghum was more beneficial. The new spacing was tried over an area of 138 acres spread over three seasons. It was found that it affords facilities for raising crops with greater surety, in years of low rainfall. In years of heavy rainfall the crop yield is not less than that obtained by following the local spacing. It also results in the saving of seeds and greater ease and quickness in intercultivation. The reduced seed rate consequent on the wide spacing of millet is 4 lb. of sorghum instead of 5 lb. For these reasons the new spacing is being now readily adopted by the cultivators. Old seed drills are now being replaced by new seed drills, to admit wider spacing. The seed drill, though it is a very important implement, is only a wooden implement shod with iron. One seed drill commands nearly 100 acres for sowing. So the number required will not be many. It has been suggested that the Government should provide at cost price new seed drills to help in popularising wide spacing of crops. This is now being done.

The local implements of the Ceded Districts are a marvel. They are very simple and very efficient. The blade harrow, the wooden seed drill, and the inter-cultivating *dantulu*, are very simple and efficient implements. They are well suited to the tract and to the bullock power available. They require to be improved for greater durability and greater ease of work at reasonable cost. The improvement of the local implements has now been taken up as an item of research by the Research Engineer of the Madras Agricultural Department.

IMPROVED STRAINS OF MILLETS

Drought-resistant strains of millets which are more suitable to the tract than the existing varieties were evolved during the previous period of the research scheme by introduction and selection. In sorghum, M. 47-3 (Bombay type) and H. 1, the local type, were tried on a large scale over an area of 250 acres. M. 47-3 is a short duration type which evades drought by ripening earlier. It was found to be specially useful in low rainfall years. H. 1 is the strain of the local variety. Its duration is 15 days longer than that of M. 47-3. In low rainfall years, its grain yield is very low. In years of normal and high rainfall its grain yield is as good as that of M. 47-3, but it always gives higher straw yield. Straw is very important in this tract. Sorghum is sown in October by which time most of the rain for the year has fallen. It has, therefore, been suggested that instead of always adopting one strain, the more suitable strain for the year should be sown, judging from the rainfall already received before sowing. If the rainfall is sufficient or heavy, Sorghum H. 1 can be sown with advantage. If the rainfall has been low, the short duration variety, M. 47-3, may be sown. M. 47-3 has been found to be more suitable for shallow soils and H. 1 for deep soils. In setaria, two strains H. 1 and H. 2 were tried over a large area and it was found that H. 1 preferred lighter soils while H. 2 preferred heavier soils. Both these strains have recorded about 10 per cent higher yields than local varieties. These strains are now being multiplied in large seed farm areas and improved seed is being made available in large quantities through departmental agencies.

A combination of bunding, improved strains and wide spacing was tried over an area of 489 acres spread over five seasons, to find out the best practice to be adopted. Bunding helps to absorb more moisture in the land and to a certain extent, neutralises the deficiency in the rainfall. As a result of these large scale trials, it was found that in the case of sorghum it was most profitable to adopt the practice of bund-former bunding and sow H. 1 sorghum at a distance of 18 in. between the lines. In the case of cotton, the best practice was found to be to put up the bunds and sow H. 1 cotton in lines 36 in. apart. These practices are now being popularized in this area.

With regard to strip cropping with erosion-resistant crops, it was found that the range of crops cultivated in this black soil area is very limited. The crops are practically only setaria, sorghum and cotton. All the three are erosion-permitting crops. Erosion-resisting crops like the trailing legumes, groundnut, etc. do not come up well here and therefore could not be included. The value of strip cropping in these soils has been found to have a very limited scope.

Manuring the fields

The problem of manuring dry lands of low and uncertain rainfall areas is a difficult one and remains to be solved. The information so far obtained shows that bulky organic manures like farmyard manure are helpful and the maximum quantities of the same should be attempted to be conserved.

The low rainfall does not provide sufficient moisture in the soil to make the manures available to the plants readily. The response is better when the rainfall is above normal, but when the rainfall goes below normal there is no effect of the manure. In fact, in heavily manured fields in low rainfall years, the yields of the crop go below normal and sometimes the crop dries up in patches. Under the prevailing circumstances, it is difficult to prescribe a proper manuring programme.

In this low rainfall area, the application of artificial manures is out of question. With regard to organic manures, farmyard manure and composts, it was found that farmyard manure proved to be more beneficial than cotton stalk composts, applied on equal nitrogen basis.

The main difficulty in the case of manuring these dry lands is the absence of sufficient quantities of farmyard manure in villages. The cattle are few and nearly 50 per cent of the cattle dung collected is burnt as fuel and the urine is not properly preserved. Fuel is scarce in these dry land villages and fuel is equally, if not more, important than manure. No improvement can be effected in the situation unless alternative fuel sources are made available. By proper land use, the marginal land should be relegated to fuel plantations. Sufficient area in a village should be put under such plantations with a view to releasing as much cattle manure as possible for the fields. More care should be bestowed on conserving cattle urine which is the best part of the manure. The conservation of the maximum quantity of cattle manure and making of composts from village waste and rubbish including human excreta is a proper subject of intensive village propaganda to obtain increased yields from judicious manuring. This propaganda has now been taken up by the department and an intensive scheme of village composts preparation is in operation.

Contour cultivation

The advantages of cultivating the land on the contour, (i. e. harrowing, ploughing, sowing, intercultivation, etc.) lie in the fact that contour cultivation offers resistance to the free movement of rain water from the land. The contour lines are at right angles to the direction of the slope of the land at every point in the line, and thus they offer resistance to the movement of water. If on the other hand, the cultivation operations are done along the slope of the land, the rows of furrows and the rows of crops will be parallel to the slope of the land and will, therefore, admit easy run off of rain water and soil erosion. Therefore, contour cultivation is a very desirable practice. This was successfully tried at the Agricultural Research Station, Hagari. It is ideal to cultivate strictly on the contour. The next best that can be done is at least to cultivate at right angles or across the main slope of the land, irrespective of the consideration of the length or the breadth of the field. This kind of cultivation may not give increased yields at once and its advantages cannot be proved by facts and figures on large scale experiments within a short time. The treatment is not like that of manuring and bunding and quick results could not be demonstrated. The cultivators were impressed with the soundness of the method when explained to them. However, under the present conditions of land tenures, size of holdings, and the general level of education of the cultivators, it is doubtful whether they can take to contour cultivation. For the successful working of this system, a unit of work will consist of a very large area. It was difficult to run contour lines on small holdings. It has, therefore, been advised that cultivation on the contour should be adopted wherever possible, or at least the cultivation should be across the main slope of the land *but not along the slope.* This is being advocated by the Department of Agriculture through their propaganda staff.

PERMANENT FIELD EMBANKMENTS

Cultivators, especially in areas of low rainfall have been alive to the necessity of conserving rain water and soil in the dry lands and felt that permanent field embankments serve the purpose. This is evident from old field bunds and big weirs which are to be seen in fields belonging to fairly prosperous villages. Very often large breaches are seen gaping in the bund at a distance from the weir, rain water for years together has escaped through these breaches, the weirs having remained functionless for ordinary rains. These features are a common sight when one goes across the fields in the interior as well as along the roads. All these point to the following facts, that (i) cultivators have realised that permanent field embankments are a

PLATE II

Contour bund

corrective to the low rainfall and soil erosion and (ii) the delerict weirs and breached bunds show that these bunds have not been put up properly.

The proper type of bunding that is necessary for dry farming areas is different from that which is required for wet or garden cultivation There is no irrigation water except the water from the scanty rainfall. There cannot be any attempt to level the land between bunds because there is not sufficient water to spread out to reach from bund to bund in this low rainfall area of 20 in. per annum. Moreover, it does not pay to incur the heavy expenditure on levelling because the yields from the crops do not compensate it. The nature of cultivation that can be adopted is of the extensive shallow type, to suit the low rainfall conditions. In prescribing the correct type of bunding for dry farming areas, the above-mentioned practical aspects of the agriculture of this tract have been kept in mind. In addition to this, it is also important to devise the type of bunding in such a way that minimum inconvenience is caused to the cultivators consistent with efficiency.

Several types of permanent field embankments were under observation during the period of the scheme. Observations on this area are briefly presented below.

Contour bunds with weirs

These were put strictly on the contour in an area of about 20 acres in 1942-43. Contour lines (Plate II facing page 17) were drawn after smoothening the sinousity of the lines. The bunds were put up by the famine labour. Waste weirs to take off surplus water were provided to this block. The slope of the land was about one per cent and the distance between the bunds was 300 feet. The base of the bund was eight feet and height three feet. However, the bunds, being built up of black soil, shrunk considerably in consequent years. The shrinkage was 10 per cent in the direction of width and 40 per cent in height. The provision of weirs facilitated the drainage of the water and it was helpful in protecting the bunds from breaches. The rain water did not stagnate in the field. The crops were good right from bund to bund. It was observed that bunds breached in certain places owing to holes made by rats. Bunds which were 14 ft. and 12 ft. wide at the base did not suffer from these breaches. The cultivators were well impressed with this kind of contour bunding with weirs and were eager to have them.

Contour bunds without weirs

This system was also started in 1943 and an area of about 30 acres was under observation. No weirs were provided. It was found that with heavy rain there was a continuous stagnation of rain water near the bund for nearly 20 days in the rainy period, the width of the sheet of water ranging from 75 ft. to 12 ft. parallel to the bund. As this delayed the cultivation of this area, three inch cement pipes had to be put into the bunds to drain the water. The dry crops did not tolerate the standing water for a long time and the plants under water perished. The provisions of pipes eased the situation. The cultivators did not like this kind of bunding as the moist area near the bunds retarded cultivation operations.

Field border bunding

Bunds were put up in an area of about 33 acres along the field borders of the holdings which were included in this area. The compartments were rectangular and the area of each varied from three acres to seven acres. No weirs were provided. Four holdings brought were under this type of bunding. It is recorded to the credit of the cultivators under the Dry Farming Developmental Scheme that they never raised any objection to whatever work that was being done in their fields whether it was to their liking or not, and it was a pleasure to proceed with work under such circumstances. This type of field border bunding proved to be the worst kind of bunding. It consumed more length of bund per unit area enclosed. The cultivators first fancied this bunding because it required no levelling instruments and they could do it themselves. Moreover, it defined and protected their property lines. But when they saw how the bunds functioned, they had to change their opinion. There were pools of stagnant water at every junction of bunds and crops could not be grown in these areas. The breaches were more frequent in this kind of bunding because all the water accumulated at one place, reached a great depth and pressed on the bund. In the case of a contour bund the spread of water is more even.

Terrace bund

A model terrace bund was put up enclosing an area of three acres. This type of bund is an important deviation from the conception of the orthodox bund The base width was 50 ft. and the height at centre was 2½ ft. sloping off in both the directions. Bullock power was mostly used to put up this kind of broad bund and it was shaped by human labour subsequently. The bund was put on the contour and was about 600 ft. long. The disadvantage in this kind of bund was that it was three times more costly to put up. The advantages are many. It is rat proof and breach proof. It can be cultivated over as ordinary ground and good crops have been grown on this bund. It practically formed a portion of the field for all purposes. It can be put strictly on the contour without affecting field boundaries, and without its coming in the way of the cultivation of each holding, independently.

With regard to weirs their necessity has become clear. Three kinds of weirs are under observation, viz. masonry weirs, filter weirs and concrete pipes. The masonry weirs were costly and it was difficult to obtain stones in black soils. The filter weir was very efficient. Pebbles and small stones that could be picked from the field itself were used for this purpose. A cut three feet wide was made on the contour bund going down to six inches below ground level. The pebbles were filled in to a height of one foot six inches. The earthern bund which was cut for inserting this was again made up to its old stage. The weir was put up for observation in 1947. The discharge of rain water was very good and water was practically filtered by these small stones. Concrete pipes with a diameter of three inches was tried in place of weirs. A catchment of four acres was drained by this pipe within 24 hours after heavy rains. This is an ideal discharge which leaves sufficient time for water to soak in and at the same time not long enough to kill the plants. There was no gully formation on the down stream side as the flow was small and spread out.

The effect of embankments on the fields and crops was very noticeable. In the embanked fields in the course of three or four years no gullies or streams could be noticed while the non-embanked fields of the same catchment showed gullies and streams. This is due to the fact that the bunds at intervals stopped the flow of running water without allowing it to gain destructive velocity. Whenever a flow of water met a bund, it was stopped and lower down the bund the water had to start again at scratch. Before this gained sufficient velocity, it was stopped by another bund. In this way erosion was checked by preventing water from running off too quickly. The old small gullies and streamlets that were running in this area before the embankments were put up, have ceased to exist in three or four years after the embankments were put in. The land became more even. With regard to the effect of bunds on crops, it was seen that the crops were better in the embanked area and gave higher yields. In *rabi* crops, sorghum and cotton, the increase in yield varied from 16 to 30 per cent. A statement of the crop yields obtained from the embanked areas as compared to those obtained from adjacent fields which have not been embanked is presented in Table V on the next page.

It will be seen from the observation in this table that permanent field embankments prevent the erosion of soil, help the conservation of more moisture in soil and give increasd yields of crops. In low rainfall years, the bunds have been more useful than in heavy rainfall years Bunds are an insurance against famine. These observations are only of a preliminary nature and were rather confined to small areas, while the subject requires large areas for more critical study. The Government of Madras have recently (1950) sanctioned a scheme of large scale experimental bunding in these arid areas. Preliminary work with regard to surveying has already been done and it is expected to come into operation during this season (1951-52).

Finally it will not be out of place to mention at this stage the advantages that have been derived by the cultivators of these arid areas by the adoption of the improved dry farming practices, as a consequence of the departmental propaganda after the termination of the scheme in 1948. In Table VI on page 26 is given an extract of information given by the Deputy Director of Agriculture, Cuddappah, with regard to the advantages derived by the cultivators of the districts of Bellary, Anantapur and Cuddappah during the year 1949-50, by the adoption of improved dry farming practices.

TABLE V

Effect of permanent field embankments (contour bunds with weirs) on crops at Hagari (1944-47)

Crop		Acre yields in pounds		Actual increase due to embankments in lb.	Percentage of increase	Value of increase		Remarks
		Embanked area	Non-embanked area					
Kharif crop								
1. Setaria	Grain	419	258	161	62.4	Rs.	as.	
	Straw	569	352	217	61.6	16	5	Average of 2 seasons
Rabi crops								
1. M. 47-3 sorghum (short duration variety)	Grain	267	230	37	16.0	8	6	Average of 3 seasons
	Straw	1,222	872	350	40.1			
2. Type 1 sorghum (long duration variety)	Grain	238	181	57	31.4	6	0	Average of 2 seasons
	Straw	1.181	1,162	19	1.5			
3. H. 1. Cotton	(*Kapas*)	213	183	30	16.5	5	0	Average of 3 seasons

Note:— Produce was valued as follows :

Setaria grain = 12 lb. per rupee
Setaria straw = 75 lb. ,,
Sorghum grain = 10 lb. ,,
Sorghum straw = 75 lb. ,,
Cotton (*kapas*) = 6 lb. ,,

TABLE VI

Economic advantages in terms of increased area, production and value for the dry farming methods adopted in 1949-50

S. No.	Improvement	Volume of improvement				Increased yield per acre average for 3 districts	Total increased yield obtained for the whole year	The value of extra income for the total area
		Bellary district	Cuddapah district	Anantpur district	Total			Rs.
1	Bunding with bund-formers	723 acres	1,744 acres	1,801 acres	4,268 acres	5 to 10 per cent	100 tons	17,000
2	Wide spacing of crops*	...	...	2,000 acres				
3	Cultivation of improved strains of millets							
	(a) *Jonna*	84,046 acres	28,509 tons	25,189 ,,	1,37,744 acres	47 lb.	2,900 tons	6,63,000
	(b) *Korra*	1 91,188 ,,	5,845 ,,	27,487 ,	2,24,520 acres	38 lb.	3,800 tons	8,43,000
4	Periodical manuring							
	(a) Application of farm-yard manure	21,795 tons	...	53,240 tons	75,035 tons	$2\frac{1}{2}$ per cent of the manure applied	1,870 tons	4,10,000
	(b) Composting with waste vegetable matter	1,297 tons	545 tons	1,336 ,,	3,178 ,,	$2\frac{1}{2}$ per cent of the compost applied	80 tons	18,000
5	Contour cultivation	...	798 acres	1,066 acres	1,804 acres		20 tons	4,000
6	Permanent improvements							
	(a) Field bunds	42 acres	...	776 ,,	818 ,,	5 per cent	20 tons	4,000
	(b) Construction of spill ways and checkdams	1,540 yards			1,540 yards			
	(e) Hedge planting	200 yards						
						Total	8,790 tons	19,59,000

*Seed drills newly distributed

It will be seen that an increased production of 8,790 tons of food grains or an increased profit of Rs. 19,59,000 to the cultivators has become possible in this State by the adoption of improved dry farming practices in these districts during 1949-50. The amount spent on the entire scheme of dry farming reseach, including the developmental phase, is Rs. 3,32,000 spread over a period of 14 years.

3

GLOSSARY

Bengal gram	...	*Cicer arietinum* L.
Danthi	...	Blade harrow to interculture in sorghum
Groundnut	...	*Arachis hypogea* L.
Hingari	...	*Rabi*, later season
Horse gram	...	*Dolichos biflorus* L.
Jadu choppa	...	Earless plants in sorghum
Jonna or *Jowar*	...	*Sorghum vulgare*
Kapas	...	Seed cotton
Korra	...	Italian millet
Mungari	...	*Kharif*, early south-west monsoon
Pathi-guntaka	...	Blade harrow to interculture in cotton
Pillipesara	...	*Phaseolus trilobus* Ait.
Safflower	...	*Carthamus tinctorius*, L.
Tanai	...	Italian millet-*Setaria italica* Beauv.

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