REPORT

ON THE

JAPANESE METHOD OF RICE CULTIVATION IN SAHARANPUR DISTRICT

(UTTAR PRADESH)

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PART I

June 1959 to October 1959

PART I

CONTENTS

INTRODUCTION

In accordance with the desire of the Embassy of Japan in India to stage a practical demonstration of the Japanese method of paddy cultivation in Indian rural areas with the co-operation of the Government of India, we four took up wetland cultivation in Sorana village of Saharanpur District in June, 1959.

This place is to the north-northeast of Delhi and is 110 miles away. It takes five hours to negotiate this distance by bus. The place commands a near-view of the mountains of the well-known summer resort, Mussoorie, and, on clear days the snowy Himalayas are visible in the distance.

The Grand Trunk Road which connects the States of Uttar Pradesh and Punjab passes through Saharanpur to Ambala in Punjab. Our farm is located at a place which is six miles to the west of Saharanpur town along the Grand Trunk Road.

This is our report on the first round of rice cultivation we pursued in the latter half of 1959. In addition to analyzing the technical and operational aspects of the results, we have attempted to record, though a little bold on our part, our views on the methods of paddy cultivation in this area based on the knowledge which we have gained by our contacts with local farmers in the short period we have been here.

CHAPTER I

ENVIRONMENT OF THE FARM

The total area of Saharanpur District is 1,356,888 acres of which 140,000 acres are wetlands. The chief crops of this area are sugar-cane, paddy, wheat, potatoes and fruits. Atmospheric temperature and precipitation in this area during the paddy growing season (*i.e.* 11th June to 11th November) are shown in Table 1.

TABLE 1

Rainfall and Temperature in the Paddy Growing Season (Weekly Average from 11th June to 11th November, 1959)

Week	Date	Maximum temperature °C	Minimum temperature °C	Rainfall (mm)
1	2	3	4	5
1st	June 11—June 17	40·2	27·2	0·0
2nd	June 18—June 24	42·7	25·7	0·0
3rd	June 25—July 1	37·5	26·2	44·2
4th	July 2—July 8	35·1	25·6	119·4
5th	July 9—July 15	33·3	25·6	3·6
6th	July 16—July 22	32·3	25·4	128·5
7th	July 23—July 29	31·5	24·5	87·4
8th	July 30—August 5	31·8	24·9	207·4
9th	August 6—August 12.	33·5	24·7	86·4
10th	August 13—August 19	30·6	23·9	176·0
11th	August 20—August 26	31·5	24·0	313·9
12th	August 27—September 2	31·3	25·9	3·1
13th	September 3—September 9	30·9	23·5	72·2
14th	September 10—September 16	30·7	23·6	36·5
15th	September 17—September 23	31·1	23·7	70·3
16th	September 24—September 30	32·2	22·8	55·6

Thus, inadequacy of drainage and irrigation facilities was one of the foremost causes for last year's poor yield. We, therefore, planned immediately to conduct water from a canal near our land and the recent completion of that work has finally solved the problem of water for the coming year.

Apart from the inadequacy of irrigation facilities, the land itself is located exactly opposite the residential quarters of the landlord where we have been living, and the road is sandwiched between the two, *i.e.*, residential quarters and the farm. In addition to being very well located, for farming, the land attracts the attention of many Indian farmers as it faces the Grand Trunk Road and is thus well suited for our purpose.

CHAPTER II

DETAILS OF CULTIVATION OPERATIONS

Our work progressed in the order indicated in Table 2.

TABLE 2

Progress of Operations

Operation	Variety		
	C.H. 4	Type I	Type III
Sowing	June 25	June 21	June 24
Fertilizer application (first round)	July 22	July 20	August 1
Transplanting	July 23	July 26	August 2
Interculture and weeding	August 6	August 10	August 16
Fertilizer application (second round)	August 5	August 16	August 18
Spraying of agricultural medicines	August 18	August 22	August 29
Harvesting	October 26	October 10	November 10

Main Operations

Following is the description of our work in regard to Type I on an acre of land.

(I) NURSERY BED

(a) Sowing—10 seers.

(b) Extra precaution was taken in regard to irrigation.

1	2	3	4	5
17th	October 1—October 7	28·6	22·2	26·7
18th	October 8—October 14	31·6	20·1	0·0
19th	October 15—October 21	31·3	19·4	0·0
20th	October 22—October 28	29·9	16·6	17·5
21st	October 29—November 4	28·5	13·6	0·0
22nd	November 5—November 11	25·6	13·8	25·4
	TOTAL			1,474·1

We embarked on our work on 10th June, 1959. Preparations for transplanting had just then been completed in the neighbourhood and the season was also a little late. Owing to these reasons, as well as the inadequacy of agricultural tools and implements in our possession, we chose only 3 acres of land instead of the proposed 10 to pursue the Japanese method of rice cultivation. This land was selected through the good offices of the Government of India and it forms a part of an estate of about 200 acres owned by Mr. Harcharan Singh.

We borrowed the land from Mr. Harcharan Singh in order to demonstrate the Japanese method of paddy cultivation. It was agreed upon between us that we were to manage the farm in whatever way we wanted and deliver to Mr. Harcharan Singh a fixed part of the harvest.

This three acre land is made up of six different farms and, till the year before last, it was under sugarcane, wheat and other crops. The land had not been used for paddy cultivation before. Therefore, irrigation facilities were not good. Provision for irrigation consisted of a single well which covered over six acres of farmland. Owing to shortage of water from transplanting to the rooting and tillering stages, the landowner obliged us by irrigating the land during the day while at night we worked with our power-driven Kubota water pump to irrigate the land. Despite this, the soil remained hardened and it was not possible for us to use the rotary weeder. As a result of this the tillering was bad and the yield fell by about 30 per cent. Further, the fourth and fifth farms, being lowlands, remained submerged under one foot of water from mid-August to mid-September, and the rice plants which had suffered from overgrowth were uprooted and thereby caused a reduction of 80 per cent in yield.

To overcome this we followed the method of preparing semi-irrigated nursery beds. In this method the seed-bed is prepared without harrowing after being ploughed, the soil is crushed and fertilizers applied. Water is first let into the shallow ditch and the surface of the bed is adjusted to the water level in the ditch. In beds prepared thus 20 lb. of seeds per acre were sown by us on 21st July. After this we used the mulch we had collected before, and later we let in water to about two inches from the surface to help germination.

If the saplings are fostered thus, it is easier to remove even the stout ones from the bed as the soil does not get hardened up. Even when the bed is drained off to prevent the overgrowth of the saplings there is no fear of the soil getting hardened. The task of removing the seedlings from the bed becomes easy, the damage to seedlings is minimized and the saplings themselves are in a fine condition.

(II) PLOUGHING

We were unable to use bullocks in our work but we were allowed the benefit of using the Kubota Rotary Tiller (5.6 hp.) in the possession of the Embassy of Japan in India. (Incidentally, during his visit to Japan in the autumn of 1958, the President of the Republic of India was presented with a Rotary Type Cultivator by the Kubota Iron Works. At the same time the Company also presented a Kubota Rotary Cultivator to the Embassy of Japan in India. Through the courtesy of the Embassy we were allowed to make use of this cultivator.) The use of the cultivator helped us advance in our work rapidly and we ploughed the entire surface twice to a depth of six inches with the cultivator.

(III) TRANSPLANTING METHODS

There are different transplanting methods of which three are given below :

(a) The square method in which the length between the rows and the hills is equal.

(b) The triangular method in which the space between rows is wide but the space between hills is narrow.

(c) The straight line method of transplanting in which the difference between rows and hills is great.

Which of these methods is good is determined according to the variety to be sown, differences in environment and the type of cultivation.

The most common method employed in India is the square method. We planned to investigate the influence of these different transplanting methods on the growth of the rice plant and the yield

(c) The seedlings remained in the nursery bed for 34 days and were removed on July 25th. Each seedling had 1 to 2 tillers and measured 7 to 9 inches in height.

(d) Fertilizer application : compost 40 maunds, ammonium sulphate 20·5 lb., superphosphate 10 lb.

We applied these fertilizers on June 16th, a week before harrowing.

(II) MAIN FIELD (PADDY FIELD)

This was formerly devoted to wheat.

(a) *Ploughing*. First round : 20th July. Second round : 22nd July.

(b) *Transplanting*. 2 plants in the space of 1 ft. × 1 ft., 36 hills per tsubo (3·3 square metres).

(c) *Fertilizer application*. For basal dressing we sprinkled 50 lb. of ammonium sulphate, 16 lb. of superphosphate on 20th July and on 22nd July we ploughed them into the soil. For topdressing we used 30 lb. of ammonium sulphate, 8 lb. of superphosphate and 50 lb. of bonemeal on 16th August after weeding and inter-tillage. The uneven distribution of fertilizers was corrected by a supplementary application of ammonium sulphate (20 lb.) and superphosphate (8 lb.).

(d) *Inter-tillage and weeding*. 10th August : weeding with the help of the mechanical weeder.

18th August : weeding with hand.

(e) *Spraying of agricultural medicines*. 22nd August to 20th September. Name of pests: leaf hopper or brown plant hopper (*H. nigrorepletus*, *H. oryzivours*,) and stink rice bugs or ear bugs (*L. variccins*).

We used 60 lb. of agricultural medicines containing 5 per cent BHC.

(f) *Harvesting*. 10th October. Quantity of grain : 40 maunds and 23 seers.

Observations on each Phase of Our Work

(I) SEED-BED

From our past experience in Bihar for over three years, we have found out that paddy seedlings nursed in ordinary wet seedbeds (*i.e.*, the method of preparing the bed by levelling and harrowing after ploughing, soil crushing, fertilizing and watering), have a tendency to overgrow and, when water is drained off to prevent this, the soil gets hardened up and the work of removing the seedlings from the bed becomes difficult, rootlets of the seedlings are cut off and the rooting of the plants after transplantation becomes poor.

its leaves and thus prevents the withering away of the plant. However, care must be taken, as a high level of water at a time when the wind is strong, or when particles of compost or tree leaves are floating on the surface of the water can cause the saplings to collapse. It is, therefore, necessary to increase or decrease the depth of water according to the size of the seedlings, quality of the soil and weather conditions. It is of advantage to keep the water level normally at about three inches and later on to reduce it gradually.

(d) *At the tillering stage*. Since in this stage the growth of the rice plant is most vigorous, any shortage of water will cause a reduction in the number of tillers. On the other hand, excess of water gives rise to the danger of overgrowth of the plants, opens the way for large damages due to harmful diseases and insects and renders it easy for the plants to lodge.

The depth of water differs according to whether the retention of water is good or bad, but generally a depth of 2 to 3 inches is maintained at the time of irrigating the field. And after the water retained on the surface of the soil has disappeared completely, the field is irrigated again.

Before the peak tillering stage and when the final weeding is over (i.e. when valid tillering is over and is followed by invalid tillering), irrigation must be temporarily suspended and the field drained off without causing cracks in it; after this, irrigation of the field must be continued again.

(e) *From the formation of young ears to the heading stage*. This is the stage when the plants are most susceptible to external conditions. Hence care must be taken to irrigate the field deeper still and not to cut off water supply. Irrigation at this stage is also called by two other names, viz., watering at the heading stage and watering at the flowering stage. A cut in water supply at this stage not only obstructs the development of the ear but the spikelet itself will not be normal. It has to be borne in mind that generally between the end of the flowering and pollination stage and the beginning of the leaning of the head (an interval of about 10 days) any cut in water supply will make the plants susceptible to drought.

(VI) INTER-TILLAGE AND WEEDING

Inter-tillage and weeding of paddy fields usually go together; the latter removes the weeds that hinder the growth of the rice plants, and the former has the effect of promoting the growth of the roots, and also hastening the decomposition of fertilizers. The frequency and the time of weeding and interculture differ considerably according to weather, quality of the soil, variety, time of transplanting, conditions of weed growth, labour and the weeding method employed.

on farm No. 1 (0.5 acres) but, unfortunately, we failed to obtain any results because the seeds supplied to us were of seven different indigenous types.

(IV) SETTING THE SEEDLINGS IN THE PADDY FIELD

There are two ways of setting the rice seedlings in the main field, viz., horizontal string method and vertical string method.

In the former, a number of people move sideways, while transplanting, along a rope and when all have finished transplanting along the line, the rope is moved and the transplantation begins along a new line. The overall speed of work is dependent upon the least efficient. However, if all members have adequate dexterity this method is helpful for uniform progress. We adopted this method.

In the latter method, as each one is responsible for transplanting about six rows lengthwise along a rope, progress would differ according to each man's ability.

We hired provisionally some workers from the neighbourhood for transplanting work. But there was a fear in us that these people might transplant the seedlings deep in the field, or break the stem while transplanting which might spoil the development of the new radical. Besides, the node intervals under the ground might extend- and the result would be the same as double transplanting. In other words, the rooting and tillering stages would be delayed. We instructed them to place the plants at an average depth of about 1.5 inches.

(V) IRRIGATION

(a) *Before transplanting*. Before the seedlings were set in the paddy field, we ploughed the soil and desiccated it as much as possible to enhance its fertility. But we irrigated the field as soon as nitrogenous fertilizers had been applied and prevented the oxidation of nitrogen in ammoniacal form, promoted the decomposition of the reduced layer and avoided denitrification.

(b) *During transplanting*. On paddy fields where irrigation can be controlled, the water level must be kept shallow (about 1.0—1.5 inches) at the time of transplanting. If the water level is too high, transplanting would be difficult and along with the flow of water the seedlings might drift away.

(c) *At the rooting stage*. When transplanting is over, the fields are irrigated. Since healthy seedlings take 3 to 4 days to strike root, they must be covered under deep water. In deep water, the saplings can stand upright without collapsing. While on the one hand it prevents the evaporation of water through the leaves, on the other, it helps the plant to absorb water through

effective in increasing the number of ears, has a greater influence on yield than the nitrogen taken in at the time of the formation of ears.

But each spikelet in the C.H. 4 variety grows into a very large size and hence the yield is increased. Therefore, nitrogen absorption at the second stage, viz., the ear formation stage, is more effective han nitrogen received in the first stage, viz., valid tillering.

(VIII) HARVESTING AND THRESHING

After heading, flowering and pollination, nutrition shifts to the tender grains and the crop attains maturity after passing through the so-called milky, pasty and yellow ripening stages.

Since growth is most vigorous for more or less 10 days after flowering, environmental conditions during this period have a great influence on the development of the paddy grain. The paddy crop attains maturity and is ready for harvest 12-14 days after pollination, 3 weeks after flowering and 40-50 days after the ears have come out.

(a) *When to harvest*. It is said that it is appropriate to harvest paddy 40-50 days after heading, but in order to distinguish that period the following criteria are suggested.

The crop is to be harvested when the axis of stem has turned yellow and the fully mature grains are ripe yellow; and the colour of the stem of the ear has turned yellow.

(b) *Harvest*. Paddy crop in India is usually harvested with a dented sickle. So far as the method of crop cutting is concerned, the file-reaping method seems to be more efficient than the rank-reaping method. In the latter method, the reaper starts cutting the crop from the right, moves his legs to the left while cutting about 20 hills, comes back to the former position, starts cutting again from right to left and thus advances gradually. In the former method, the harvester neither moves to the right nor left but moves forward while easily cutting about 6 hills.

It has been our experience that the latter method involves 10 per cent more time than the former. In the former method the number of hills and rows that a single reaper can cover differs according to the space between hills, the number of tillers, and the number of hills one can hold at a time; but generally the area to be covered by a single harvester is determined on the basis of how many hills he or she can hold with one hand. The entire paddy crop in our land had been lodged at the time of harvesting as those in the ordinary wetlands of India.

(c) *Threshing*. Threshing in India is carried out mainly with bullocks, while in some cases the rotary pedal thresher is also used.

(a) *First weeding*. The rice plant strikes root at the latest within 7-12 days after it is transplanted; hence it is better to carry out the first weeding as early as possible after the plant is rooted. That is to say, the appropriate time to carry out this is the 12th to 15th day after transplantation. As it is also the time when inter-tillage is most effective, we accomplished this work with the help of a mechanical weeder. With the first weeding over, the growth of the rice plant becomes luxuriant. Two or three days after the first weeding we took up the work of scratching the base of the hills to remove weeds and put the mud around the roots.

(b) *Second weeding*. We carried out the second weeding 7-10 days after the first one with the same mechanical weeder. However, inter-tillage during the second weeding is not so effective as during the first. Further, the roots of the rice plant become longer at that time. Therefore, it is necessary to concentrate more on weeding than on inter-tillage and care has to be taken not to hurt the roots.

(VII) FERTILIZER APPLICATION

The quantity of fertilizers required by the rice plant varies according to the stage of its growth. Although the total quantity imbibed may remain the same, the amount of rice yield differs greatly according to the time of fertilizer absorption. In the case of nitrogen, for instance, it is said that until the stage of valid tillering is over the rice plant takes in nearly 50 per cent of what it would during the entire period of its growth.

Generally, there are two stages when the quantity of fertilizers taken in has a great influence on paddy yield. One of them is the peal tillering stage (about 30-50 days before bedding, during the valid tillering period). The other is the stage when the young ears are formed.

In the first case nitrogen absorption increases the number of ears and hence the yield. In the second case nitrogen absorption increases the number of grains (seeds) in each ear and enriches the grain as a result of which the yield is enhanced. As the effect of the nitrogen absorbed in these two stages differs from the panicle-number type to the panicle-weight type, it is of utmost importance to find out whether the variety used belongs to the panicle-weight type or the panicle-number type.

As a result of our partial management last year we discovered that Type I (Lalmati) and Type III (Basumati) were of the panicle-number type, and C.H. 4 of the panicle-weight type. That is to say, Types I and III are a variety in which the number of ears per plant is large and as a consequence the yield is high. The nitrogen received during the stage of valid tillering, being

In the above table, cost of production does not include charges of the self-supplied labour by us and depreciation charges of the agricultural implements (we used only the Kubota Power Tiller). Therefore the 'cost of production' as well as 'net profits' as used above do not convey the true meaning.

We cannot appraise the results of our work in the true perspective by totalling all costs of production of the year's rice crop because an area of three acres was too small for the labour of all four of us while the power tiller represented over-investment.

We have been thinking of bringing out soon the results of our work and comparing the results of management by Indian farmers with our own. For this reason we have also been desiring to have the minimum number of acres for a fuller utilization of our labour and the Japanese agricultural machinery in our possession.

In the analysis that follows we wish to confine ourselves to describing the details of the cost of production noted above and the distribution of labour hours.

Analysis of Cost of Production :

TABLE 5

Details of Cost of Production	Rs.
Seed and seedlings	5·00
Manures and fertilizers	70·38
Water charges	20·20
Small agricultural tools	66·25
Pesticides and insecticides	6·75
Labour charges	84·29
TOTAL	252·87

TABLE 6

Distribution of Labour Over Each Work

(Per acre)

Name of work	Number of hours	Per cent of total labour
Seed-bed	147·5	18·0 per cent
Ploughing and puddling	30·0	3.6 per cent
Pulling the seedlings	81·0	10·0 per cent

Threshing with bullock is very primitive and often results in plenty of broken rice. As the agricultural equipment from Japan did not reach us in time, we relied on the native method of threshing.

This method involves the use of 5 to 6 heads of bullocks and the labour of two men to thresh an acre's yield in a day. While one of the men is herding the oxen the other turns over the rice straw.

CHAPTER III

RESULTS OF OUR MANAGEMENT, ANALYSIS AND APPRAISAL

Results of our management :

TABLE 3

Quantity of Harvest

Variety	Farm No.	Area acres	Actual maunds	Yield seers	Yield per acre maunds	Yield per acre seers
C.H. 4 . .	1 and 4	0·7	23	10	33	9
Type I (Lalmati) .	2	1·1	44	25	40	23
Type III (Basumati)	3 and 5	1·0	38	10	38	10

NOTE:— The national average yield per acre in India is 1,198 lb. (Indian Agriculture in Brief, Fourth Edition, p. 58). This is a little above 14.56 maunds. The average in the neighbourhood of Saharanpur District is about 15 maunds. It has been mentioned to us several times that the maximum yield is 35 maunds. This is so in the case of only a few farmers and that too on parts of the cultivated land.

TABLE 4

Profit and Loss Account

	C.H. 4		Type I		Type III	
	Quantity	Amount	Quantity	Amount	Quantity	Amount
Cost of Production	About 252·87 rupees per acre (average)					
	mds. seers	Rs.	mds. seers	Rs.	mds. seers	Rs.
Harvested grain	33 9	332·25	40 23	446·23	38 10	497·33
Estimated yield from rice straw	49 0	49·00	60 0	60·00	57 0	57·00
Total gross returns		381·25		506·33		554·33
Net profit .		128·38		253·46		301·46

(II) HARVESTING

The C.H. 4 early variety attains maturity around 12th September and this is the proper time for its harvest. But we actually harvested the crop on 6th October. Therefore, between the period of maturity (i.e. 12th September) and the time of harvesting (i.e. 6th October), nearly 50 per cent of the grains had fallen down.

For the coming year, however, we wish to select the seeds by the specific gravity method (i.e. through immersion in saline water) and disinfect them.

(III) ON THE INADEQUACY OF IRRIGATION FACILITIES

Owing to incomplete irrigation and drainage arrangements it was not possible to irrigate the land sufficiently from the rooting to tillering stages. As noted earlier, irrigation provision consisted of a well which covered an area of over six acres. The water in the well could be exhausted by working our Kubota diesel water pump (5.6 h.p.) for two hours; it would take not less than an hour for the well to be full again. It was impossible to use this well to irrigate the landlords' three acres of land as well as our own three acres.

Notwithstanding the fact that the landlord irrigated his field in the daytime, and we at night (from 22nd July onwards), the soil remained hardened and, as it was totally impossible for us to use the rotary weeder, we were unable to carry out interculture and weeding. For this reason tillering was checked. This, along with the shortage of water at the time of ear formation, became one of the most important causes for yield decline.

(IV) IMPERFECT DRAINAGE

Our farms number 4 and 5 (0·6 acres) being low-lying lands remained submerged under water for about a month after the rains in mid-August (rainy season). On account of this, tillering was hampered. There was an overgrowth of the rice plants as a result of which they collapsed. The entire yield was thus wiped off on these farms.

CHAPTER IV

THE TECHNIQUE OF PADDY CULTIVATION AND OUR OBSERVATIONS ON AGRICULTURAL PRACTICES IN SAHARANPUR

Different techniques of paddy cultivation are employed according to weather, natural features, soil and other natural conditions. In view of the close interrelationship between these different techniques, it is not possible to choose any one of them independently and discuss its merits and defects.

But we wish to note here some of the most important and basic technical aspects of paddy cultivation which are commonly known among Japanese farmers but which are, according to our spot observation, relatively neglected by Indian farmers.

Name of work	Number of hours	per cent of total labour
Transplanting	139·0	17·0 per cent
Interculture and weeding .	54·0	6·6 per cent
Spraying medicines	8·5	1·4 per cent
Fertilizer application	39·0	5·0 per cent
Irrigation	57·0	7·0 per cent
Harvest and carrying	110·0	13·5 per cent
Threshing and winnowing	146·0	17·9 per cent
TOTAL	812·0	100·0

Appraisal of Results :

The yield was considerably lower during the year because the seeds of C.H. 4 variety supplied to us by the Agricultural Extension Office were largely mixed with a wild variety and the facilities for drainage and irrigation were inadequate. If these conditions are improved and facilities provided, it appears to us that the per acre yield can be easily raised to 60 to 70 maunds for C.H. 4, 60 maunds for Type I and 45 to 50 maunds for Type III. Further details about the work are given below:

(I) THE RATIO OF INDIGENOUS VARIETY IN C.H. 4 SEED

Sample cutting of 1 *tsubo* of wetland under C.H. 4 (distance between hills $10'' \times 10''$) revealed that of a total of 545 plants of 50 hills per *tsubo* the percentage of mixture of different varieties was as shown below:

(a) Early variety	216 plants	40 per cent
(b) Late Variety	121 plants	22 per cent
(c) Indigenous or wild Variety	208 plants	38 per cent

Indigenous (or Wild) Variety :

(A)	65 plants	12 per cent
(B)	49 plants	9 per cent
(C)	44 plants	8 per cent
(D)	39 Plants	7 per cent
(E)	11 plants	2 per cent

(c) *Dry seed-bed.* After sowing the bed under upland conditions, it is to be watered and, till germination is over, is to be cared for in much the same way as the wet nursery-bed. Only the ditch is flooded for several days after germination. Later, water must be drained off completely and dry conditions created. The bed is to be watered at the time of removing the seedlings.

This method shows a good result under high temperatures because the seedlings do not overgrow. This method seems to be prominent in this area.

(d) *Semi-irrigated nursery-bed.* In the beginning the entire surface is watered in the same way as the wet nursery-bed, but in later stages only the shallow footpath ditch is flooded and the seedlings are nursed throughout under humid conditions. Germinating as well as the tender seedlings are taken care of by water. Later the overgrowth of the plants, following a rise in temperature, is prevented by draining the surface of the bed. This method has the advantages of both the wet and upland nursery-beds.

We fostered most of the seedlings in raised nursery-beds which gave the best results among the four methods described above.

The location of the seed-bed is an equally important matter. In the first place, the bed must be suitably located for supervision. Secondly, it is better to avoid a site where vehicular traffic is heavy or a site into which there is a flow of drain and foul water.

(II) THE QUANTITY OF SEED

It is dangerous to unconditionally regard some quantity of seed as the appropriate one for sowing. The quantity depends upon the variety and the natural conditions prevailing.

However, thin sowing in general shows better results. This is so because the tillers of a thinly sown seedling would be many and strong, the stem would be thick and the growth of the plants luxuriant. However, care must be taken to avoid too thin a sowing which might produce well tillered seedlings in the bed itself. In our place we often come across nursery beds with tillered seedlings; if the thinly sown seedlings become tillered in the bed, it might invite adverse reaction and the tillers coming out after the plants are set in the main field might be few in number.

We don't wish to say much about weeding, top-dressing, disease and insect control and other practices on the seed-bed as these seem to be fairly widely known, but we feel that there is a need for greater attention and care in all these operations.

(III) NURSING DAYS

The number of days for which the seedlings must be allowed to remain in the bed differs according to the variety used, the location and weather conditions, but, from the viewpoint of the rooting

Seed

(I) SEED SELECTION AND SEED DISINFECTION

It is absolutely necessary that the seeds be pure, clean, well filled-up and possess a stout potentiality of germination, They must not be sealed off or mixed with hulled rice. Hulled rice gets putrefied in the seed-bed and causes plant rot.

Seeds must be necessarily disinfected. The method of disinfection is very simple: the seeds are soaked in 1/1000 Usplun Solution (the major component of which is phenyl mercury chloride containing 25 per cent mercury) for over six hours.

(II) SEED SELECTION BY SPECIFIC GRAVITY METHOD

The seeds must be put into 20 kg. of water containing 4 kg. of salt and stirred well. After removing the poor ones completely the seeds must be washed in clean water.

(III) FORCING GERMINATION

To get uniform germination the seeds must be well soaked and saturated in water. They must be soaked for over 12 hours.

It has been our observation here that none of these things are universally practised. In paddy farming, as the 'yield of rice is half determined in the nursery,' to get good seedlings which cannot be obtained without paying heed to seed selection is of utmost importance. We have been instructing the farmers here on this as and when required.

Nursery-beds

(I) TYPES OF SEED-BEDS

There are several types of seed-beds but we consider the following as the typical ones that are applicable to this area. These include the raised as well as the level seed-beds.

(a) *Normal seed-bed* (*wet seed-bed*). The bed is first ploughed and irrigated. After puddling is over, the bed is flooded normally. The tender plants are sustained by water and weeds are removed.

(b) *Upland seed-bed*. As the seedlings grow under upland conditions, their growth will be uneven and they are easily affected by weather. The time of transplanting is not very much fixed. Damage due to pests, insects and beasts is great and the pulling of the seedlings from the bed difficult. The rooting of the plant after it is transplanted, and its growth later are vigorous in rich soil. But on poor soils, the plants are susceptible to occasional "Akiochi" (disease of paddy due to lack of iron and manganese in degraded paddy soils). The growing seedlings are susceptible to blast (*Piricularia oryzae* Cav) but they are less susceptible to over growth; the growth of their radicles will be fine and their rooting capacity after transplantation great.

be transplanted on the basis of the transplanting time and soil and fertilizer conditions. Thus, when the soil and fertilizer conditions as also other factors remain unaltered, early transplanting of fewer seedlings per hill is advantageous. When transplanting is delayed, close spacing of a large number of seedlings is common. Thin spacing is beneficial in warm and fertile regions while close spacing is advisable in cold and infertile regions.

When abundant fertilizers are applied, plants are thinly spaced ; when the fertilizers are applied in small quantity the plants are thickly spaced. In the former case the square method of transplanting is convenient while in the latter the rectangular method.

In considering transplanting density, account must be taken of the variety used also.

(c) *Precautions in transplanting work.* The skill of the transplanter may very well be conducive to raise efficiency in transplanting, but it is essential to make perfect arrangements and avoid waste in the work. That is to say, pulling, carrying and allocating the seedlings are all to be carried out in good order. The work itself must be organized in such a way that there is always a bundle of seedlings within close reach of the transplanter.

The next important thing in transplanting is to set the saplings always lightly in the field. When the seedlings are set deep in the soil their primary stem node lies buried deep beneath the surface, the nodes from which the tillers come out are rendered ineffective, tillering begins at top nodes, the period of valid tillering is shortened, and the number of tillers is reduced.

The appropriate depth is between 1 to 1·5 inches. The seedling must be held between the thumb and the first and second fingers, and must be pushed into the soil.

Deep planting can easily break the stem of the plant. In our observation of the transplanting method followed here, it was clear to us that a majority of the transplanters were planting broken plants. Setting a maimed plant in the soil delays its rooting by about 10 days, greatly hurts its rooting potentiality, shortens the tillering period, reduces the number of tillers in the plant and thus exercise a great influence over yield.

Further, we have also noticed the cutting off of well-tillered seedlings and transplanting them. This is objectionable for the same reasons noted above.

Finally, complementary planting must be carried out two to three days after the original transplanting is over.

potentiality of the seedlings, it is well to remove them when they are still young. We left the seedlings in bed for over 30 to 35 days.

The Main Field

(I) HARROWING

The purpose of harrowing is to improve water retention, eliminate weeds, facilitate transplanting, help the rooting of the seedlings and mingle fertilizers with the soil. The most important of all, however, is that it evens out the ups and downs in the field.

Harrowing is an indispensable condition for a rational management after transplanting. The unevenness of the farm requires an unnecessarily large quantity of water at the time of irrigation and makes it difficult to carry out interculture and weeding satisfactorily. Also, the effect of interculture and weeding would not be uniform. The result of this is a tremendous difference in growth.

Worst of all is the fact that there are occasions when the plants in depressed areas submerged under deep water start collapsing and cause a chain reaction in the surrounding areas. This becomes one of the factors causing yield decline.

Harrowing seems to be extremely simple, but in reality no great attention is given to it. The method of harrowing we have seen here consists of the levelling of the soil surface with a 10-15 feet long, 3-5 inches thick and 1.5-2.0 feet wide plank called *chyonki* (*mailu*) which is drawn by 2 to 4 oxen. This method possesses the merit of being efficient. But as it only presses down the surface of the earth, it fails to completely fulfill all the objectives of harrowing noted before and it also leaves the unevenness as before.

In Japan, harrowing is performed with the help of the ox-drawn *maguwa* (a kind of hoe). This method requires about 3-4 hours per acre and, in comparison with the *chyonki*, is less efficient. But it fully attains the objectives of land adjustment and land levelling.

(II) TRANSPLANTING

(a) *The methods of transplanting.* There are the square method, the rectangular method, the triangular method and the straight line method. Which one of these is to be preferred varies according to soil conditions (whether fertile or infertile), plans of fertilizer application (whether more fertilizers or less), and changes in the agricultural implements and tools used.

(b) *Transplanting density.* Whether fewer or more seedlings are transplanted has a close bearing on yield. Generally, the yield increases as the number of plants transplanted is increased. But it is better to determine how many plants are to

The effectiveness of inter-tillage of the soil surface varies according to the quality of the soil and the depth, frequency and time of inter-tillage. Generally, deep inter-tilling considerably reduces the disappearance of moisture, but, as this involves the risk of injuring the roots, it is desirable to carry out surface tilling to a depth of about 3-4 centimetres. It is better to carry out inter-tillage as soon as the water supply is cut off; but it is not good to carry it out too early and leave the surface to get hardened up. In general, it is expedient to carry out inter-tillage on sandy soil immediately after suspending water supply, and, on loamy soil, before any cracks appear on the surface.

This must be followed up soon by covering the space between the rows of rice plants with straw, compost and wild grass. The effect of moisture preservation by thus covering the field would be sufficiently great.

(c) *Planned distribution of water*. That paddy is grown by flooding water is popularly known. Hence one is prone to think that a high water level is essential for paddy. But it is clear from a number of experimental records that as the level of water is raised, the yield goes down.

Irrigation is particularly difficult in usually drought-stricken areas; in most cases irrigation is well nigh impossible in times of drought. Therefore, a rational method of irrigation which gives the maximum yield with the minimum quantity of water ought to be followed in such regions.

NOTE : 1. Growth period in each stage is between 10-13 days.

2. The period of ear formation for each variety is determined by a calculation backward from the expected heading days.

(IV) HINTS ON CARRYING OUT PLANNED DISTRIBUTION OF WATER

(a) In irrigated areas served by one and the same tank, varieties which have roughly the same phases of growth must be sown. When a number of varieties with different phases of growth are used, not only the planned distribution of water becomes difficult but its effect is lessened and irrigation water is wasted.

(b) *Transplanting at the right time must be adhered to strictly*. Transplanting may be carried out even after a little rainfall. Also it is necessary to arrange for transplanting in a group so as to reduce the time needed for transplanting. When the time taken for transplanting is too long, the irrigation water is wasted and a disparity in the phases of growth of the early and late varieties is created. There is also the danger of a diminution of the effect of planned distribution of water.

(III) IRRIGATION

(a) *Irrigation control* (*management*). Briefly, the water level must be raised after transplanting and reduced after the rooting of the plants and during interculture, weeding and top-dressing. If necessary, it can be drained off during interculture, weeding and top-dressing.

The quantity of water required by the rice plant varies according to the stage of its growth. A fairly large quantity of water is needed during the transplanting and rooting stages, throughout the ear formation stage and during the heading period. In other stages a very small quantity of water is enough. Particularly around the period of invalid tillering an extremely small quantity of water is sufficient.

If there is no water immediately after they are transplanted, the rooting of the rice plants will be delayed and the end result will be the same as late transplanting. This might lead to a decline in yield. Further, maximum water is needed from the ear formation stage through the entire period of reduction division of pollen and embryosac mother cells (i.e., watering at the heading stage and watering at the flowering stage); if the plants suffer drought during these stages (due to water shortage) there would be considerable decline in yield.

Contrary to this, there are situations when a suspension of water supply may result in a favourable yield. This is what is generally called *Nakaboshi* (i.e., the draining and drying of the paddy field before the earing date). In warmer regions, *Nakaboshi* must be practised especially to prevent the *Akiochi*. The field is drained and desiccated in order to check the excessive response to nitrogen at the time of invalid tillering and reducing of tillering. It is also practised to help a robust growth of the rice plant and to preserve suitably the response of fertilizers after the ear formation stage. The appropriate time for this process is the period between the stoppage of tillering (i.e., about 35 days before the heading) and the young ear formation stage. The number of days during which water is to be cut off differs from place to place and it cannot be said generally how many days are good, but the field can be drained to the extent that such draining does not give rise to cracks in the field. In order to carry out proper draining and drying of the field, it is imperative to understand clearly the phases of growth of the rice plant and have perfect irrigation facilities.

(b) *Problems of preventing drought in the main field.* The disappearance of moisture from the soil through capillary action under severe drought conditions causes parched cracks on the surface of the field. Interculture and covering of the earth are among the practices followed to prevent this.

1	2	3	4
Ear formation	Most required	Supply several times	One or two rounds of irrigation
Leaning of head	Most required	Supply several times	One or two rounds of irrigation or moisture
Heading and flowering	Required	1-2 rounds of irrigation or only for moisture	Moisture
Pasty ripening	Required in small quantities	Moisture or suspension of water supply	Suspension of water supply
Yellow ripening	Required in small quantities	Suspension of water	Suspension of water supply
Fully ripened	Required in very very small quantities	Suspension of water	Suspension of water supply

(h) If water supply is cut off throughout the tillering period, it may not often be possible to flood the field, even if irrigated, in the ear formation stage. In such cases there is no other way save that of maintaining humid conditions.

Further, care must be taken that irrigation water is sufficiently warm, free from poisonous substances and weeds and seeds.

(V) INTERCULTURE AND WEEDING

Weeding eliminates the weeds which vie with the crop for water and nutrients while intertillage possesses the effect of promoting the decomposition of fertilizers. The latter is all the more effective under high temperatures. Hence, interculture which is carried out at a time when there is maximum temperature in summer is most effective.

If we examine the work of removing weeds from the point of view of labour power, we find that weeding by a man-driven machine (e.g. rotary weeder) requires some 20 to 40 per cent of the labour power required for weeding by hand; weeding by animal-drawn machine requires 10 to 15 per cent of the labour power required for weeding by hand.

(VI) METHODS OF FERTILIZER APPLICATION

Any attempt to realize a large yield by the application of large quantities of fertilizers and through directly feeding the

(c) An appropriate quantity of fertilizers, particularly compost, must be used.

(d) Immediately before cutting off water supply, interculture and weeding must be carried out, preferably with a rotary weeder. If this is neglected there is a chance of a wild growth of weeds when water supply is suspended.

(e) When water supply is suspended, the formation of cracks on the surface of the soil should be prevented. In order to preserve the moisture, the soil surface must be covered with wheat straw (about 40-60 maunds per acre) or inter tillage to a depth of 2-3 centimetres from the surface must be carried out.

(f) The stage of ear formation must be properly judged.

(g) Weeding must be practised when water supply is suspended as otherwise the period is conducive for a thick growth of weeds.

In this connection it is necessary to carry out a planned distribution of water after knowing well the relation between drought and the stages of growth of the rice plant, the degree of moisture needed at the different phases of growth and the adaptability of the paddy variety to drought.

Water must be economized throughout the tillering period when much of water in the field is least effective and also when the adverse effects on the crop from suspension of water supply are the least. Water is supplied in abundance after the ear formation stage; the extent of the increase or decrease of it depending upon the available water supply. The method to be followed is roughly indicated in Table 8.

TABLE 8

Planned Utilization of Water

Growth Stage	Extent of irrigation water required	Method of planned distribution of water	
		When irrigation water is poor	When irrigation water is very poor
1	2	3	4
Rooting	Most required	Continuous supply	Compound water and moisture
First tillering	Required	Supply only for preserving moisture	Suspension of water supply
Second tillering	Required	Supply only for preserving moisture	Suspension of water supply
Peak tillering	Required in very small quantities	Suspension of water supply	Suspension of water supply

(b) When ammonium sulphate is used as the basic fertilizer, sub-surface placement of fertilizer must be carried out (about 4-5 inches deep) and within 5 days the soil must be prepared for watering. Supplementary fertilizers must not be spread when the water level is high and care must be taken to let the soil absorb fertilizers swiftly in shallow water.

(VII) DISEASE AND PEST CONTROL

What was surprising to us in Saharanpur was the complete ignorance of farmers (as well as landowners) about the damage caused by brown plant hoppers (leaf hoppers) (*Hieroglyphus banian*, *H. nigrorepletus*, *H. oryzivorus* *Oxya velox*, *F*). They knew that there were outbreaks of these insects on many occasions before, but they never devised any measures to check them.

There are many kinds of leaf hoppers but they all injure the plant by absorbing the nutrients directly meant for the plant and by carrying the dwarf disease (stunt) virus.

The outbreak of these insects can be prevented by spraying Pyrethrin and D.D.T. dust or emulsive liquid. An extremely simple way is to follow aphis extermination practice. By carrying out the complete shedding after this practice once on the main-field and on the seed-bed, nearly 30 per cent of the insects can be eliminated.

Besides the brown plant hopper (leaf hopper) there are other diseases and pests causing damage to the rice plant. Chief among them are blast (*Piricularia oryzae*) brown spot (*Cochliobolus miyabeanus*), stem rot (*Schoenobius*) *incertulas*,) dwarf disease, gundhi bugs (rice bugs, stink bugs, or rice ear bugs) (*Leptocorisa acuta*, *L. varicornis*), rice borer (rice stem borer) *Schoenobius incertulas*, and locust. It appears that no protective measures are adopted against these and farmers themselves seem to have no interest in the matter.

We believe that it is not at all difficult to raise production by 10 to 15 per cent if prevention measures against diseases and pests are adopted more fully.

It is totally meaningless to carry out disease and pest extermination work individually ; its effect will be insignificant if it is not undertaken by organized groups.

To enlighten the farmers more, this problem needs to be tackled by Community Project and other organizations. To give an instance, farmers in this neighbourhood who had watched us spraying pesticides and fungicides (in our farm) came to us

paddy plant with fertilizer ingredients is fraught with great danger. A pre-condition for larger yield is an improvement in the fertility of the soil. No amount of labour and fertilizer application can bring large yields on poor soils.

First of all, what is important is that the soil must be ploughed deep, new soil added, top-soil ploughed deep, large quantities of compost and manures added and the soil desiccated before irrigation.

It is extremely difficult to lay down what constitutes an appropriate quantity of fertilizers under all circumstances. We have often been asked here about what quantity of fertilizers we used and whether plenty of chemical fertilizers are used in the Japanese method of paddy cultivation. Actually, we used only the quantity of fertilizers ordinarily used in Japan. We think that the quantity of fertilizers must be, as far as possible, in keeping with the fertility of the soil.

From what we have seen here we think that there is a great bias in favour of inorganic fertilizers. When the quantity of fertilizers used exceeds the fertility of the soil, it not only leads to a degradation of the paddy field but also gives rise to the risk of the lodging of the plants and a greater attack by diseases and pests.

We feel that the lodging of the rice plant is a great problem in paddy farming in Indian rural areas.

The Indian variety of paddy lodges easily, but this can be countered by the application of potassium fertilizer. So far, the potassium contents of the soil in India have been said to be rich, and hence potassium fertilizers are applied in small quantities . In fact, it is extremely difficult to get potassium fertilizers in our own place and we supplemented the supply of potassium with bone dust. This question seems to need further examination.

The increment in yield following fertilizer application needs some examination from the point of view of farm management also. To say the least, it is obvious that the rate of increase in the yield per unit of fertilizer used declines as the quantity of the fertilizers is increased.

The following points regarding the methods of fertilizer use must be borne in mind :

(a) Both slow-acting and quick-acting fertilizers could be used in roughly equal halves as basic fertilizers, while for top-dressing (split application) only the slow-acting ones could be used. When nitrogen is used for top-dressing due attention must be paid to the quantity and the time of application. Otherwise there is the danger of inviting an outbreak of diseases and pests.

and unaffected by harmful insects and diseases. It is possible for a single person to gather about 30 seers per day. What has to be borne in mind in this regard is that for each acre of the following year's anticipated area to be planted under each variety, around 10 to 12 seers have to be collected. From among the ears gathered, half of each ear from its top must be preserved for use as seeds. The quantity of seeds to be gathered must be roughly twice as much as the quantity required for sowing plus the estimated reduction (about 5 per cent) in quantity under seed selection by immersion (i.e., specific gravity method).

On the Japanese Method of Paddy Cultivation

Finally, we wish to record candidly the impressions we gained, in a short period, on what is known in this area as the Japanese method of paddy cultivation.

A reference has already been made by us to several points in its proper context, but, if we were to give an overall picture, it appears that the method of introducing the Japanese method of paddy cultivation into this area has been abstract. The local experts (officers) have only theoretically accepted it; and the reception on the part of the farmers has been extremely formal. Knowledge about the Japanese method of paddy cultivation is confined only to transplanting in lines, interculture and weeding and heavy fertilizer application. We found that the close attention and care necessary to make the best use of each operation were lacking, because of the lack of understanding of the technical significance of it.

We have often received complaints that under the Japanese method of paddy cultivation yields have been incommensurate with the large quantities of fertilizers applied. But this is, in a sense, a natural outcome. It would be strange if the fertilizer application beyond the capacity (fertility) of the soil did not cause disease, pest attack and lodging of the rice plants and thus leading to a reduction in yield. This is all the more so when the study and practice of the mutually related aspects of cultivation and management are divorced.

Thus viewed, we think that in the Japanese method of paddy cultivation pursued in this area the quantity of fertilizers used is excessive. Nevertheless, there are instances where the Japanese method of paddy cultivation has shown favourable results as, for example, in the Serpur region. After knowing the local conditions well we wish to render our services, little though they may be, for the improvement of agricultural techniques in Indian villages.

frequently and sought our assistance in spraying agricultural medicines to eliminate the virulent pest attack which was causing them trouble.

These farmers seem to be unaware of the location of the Government agency for disease and pest prevention and also how disease and pest control is organized. We feel it urgent that some administrative measures should be taken to improve this situation.

(VIII) THRESHING AND WINNOWING

Threshing and winnowing methods here are wholly primitive Threshing is commonly carried out by treading under the feet of 4 to 5 bullocks. This method is claimed to be rather efficient. But the rice straw obtained after threshing (by this method) being much broken, loses some of its value as animal feed and thus leads to a reduction in gross returns, unless it is used. for compost.

Threshing by the beating method requires human labour- Although this method is free from the shortcomings of the trampl ing method, it is inefficient and is not conducive for a rational distribution of labour power. Another disadvantage of this method is that it is costly.

Notwithstanding that threshing and winnowing are chain processes, the two are carried out as if they were totally different. Generally, winnowing in this area is carried out with wind which, requiring much labour, prevents a rational distribution of work.

In order to economize labour power and to attain a rational distribution of labour there is no other way save that of popularising improvements in agricultural implements and tools. As devices like the pedal thresher and winnower are not particularly costly, all farmers must be equipped at least with them.

We also suggest that some method of group-buying of one power thresher for each village be considered. In so far as farmers in the neighbourhood of Saharanpur are greatly attached to agriculture, the need for this will be felt by them very keenly.

(IX) SEED GATHERING

It seems that practically no attention is given to seed collecting. It goes without saying that seed gathering is a fundamental thing in paddy cultivation.

The method to be followed in seed gathering is to enter the field a week before the scheduled harvest day and gather fully grown ears which are heading from robust stem, rich in grains

and unaffected by harmful insects and diseases. It is possible for a single person to gather about 30 seers per day. What has to be borne in mind in this regard is that for each acre of the following year's anticipated area to be planted under each variety, around 10 to 12 seers have to be collected. From among the ears gathered, half of each ear from its top must be preserved for use as seeds. The quantity of seeds to be gathered must be roughly twice as much as the quantity required for sowing plus the estimated reduction (about 5 per cent) in quantity under seed selection by immersion (i.e., specific gravity method).

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The average number of observers coming to us exceeded 50 persons a month.

On September 26, the chief of an agricultural training school which is located at a place 14 miles from Saharanpur came for observation along with 30 trainees. After we had explained, in a general way, the management practices of the Japanese method of paddy cultivation from the seed-bed to harvest, the chief of the training school told us that, though nearly 80 per cent of the wetlands in the neighbourhood were planted according to the normal Japanese method, there were some unsuitable practices on account of inadequate knowledge about it. We were invited to Rampur to guide the trainees in the school as well as farmers.

CHAPTER V

INTEREST EVINCED BY NEIGHBOURING FARMERS IN OUR ACTIVITY

What was surprising to us when we arrived in Saharanpur was the publicity given to the Japanese method of paddy cultivation everywhere and the remarkable earnestness with which farmers were studying it.

Thus, it is quite natural that interest in the agricultural practices pursued by us has been greatly heightened from the beginning of our work in the small farm. Particularly in the transplanting season an average of 30 to 40 experts and farmers visited us every day for observation. We discussed with these people the Japanese method of paddy cultivation through questions and answers ; concrete talks centred around problems like seed gathering, seed selection, selection by immersion in saline water (i.e., specific gravity selection), seed disinfection, seed-beds, transplating, interculture and weeding, fertilizer application and irrigation.

Those who came for observation listened to us with enthusiasm, questioned us and, on return, passed on to other villagers what they had heard.

As we are frequently asked to visit villages in connection with fertilizer application and the prevention of harmful pests and diseases, we go out and counsel the villagers whenever we have time to do so. On a particular occasion when the entire area of a village had been attacked by brown plant hoppers, arrangements were made by us from pesticides and fungicides to sprayers (dusters) ; and along with the farmers, we sprayed the agricultural medicines.

The following were some of the important observation teams which visited us :

(1) August 6 : 50 officers of the Saharanpur area *Panchayat*.
(2) August 8 : 50 persons besides the Chief of the Agricultural School of Saharanpur.
(3) August 16 : 30 agricultural experts from all over India.
(4) September 2 : 12 people besides the head of the Hardwar Agricultural School.
(5) September 24 : Chief of the Meerut Agricultural Experiment Station.
(6) September 26 : 30 persons besides the chief of the Rampur Agricultural Training School.
(7) Chief of the Agricultural Office of Saharanpur along with another observer.

PART II

October 1959 to June 1960

PART II

CONTENTS

INTRODUCTION

This part is meant to supply information to the interested parties on the experimental cultivation of wheat and paddy (second crop) in succession to the first paddy crop.

Admittedly this part is not intended to set a decisive and final judgement about the general feasibility and profitability of two croppings of paddy in this area which has been locally believed impossible. It is an interim report of our experiment along this direction and is, at the most, suggesting some hints for universalisation of this practice with the merit of the encouraging results so far obtained through our efforts. Impartial study and frank criticism to our approach are earnestly looked for.

The area cultivated during 1959 *rabi* season was : wheat two acres; fodders and green manures one acre; and second paddy crop 1/5 acre.

CHAPTER I

WHEAT CULTIVATION, 1959

Temperature and Precipitation During Wheat Cultivation Period

Weekly average of both temperature and precipitation (rainfall) from October 15, 1959, to April 1, 1960.

Week	From—to	Temperature		
		Maximum °C	Minimum °C	Rainfall (mm)
1st	October 15—October 21	31·3	19·4	0
2nd	October 22—October 28	29·9	16·6	17·5
3rd	October 29—November 4	28·5	13·6	0
4th	November 5—November 11	25·6	13·8	25·4
5th	November 12—November 18	25·0	9·8	0
6th	November 19—November 25	24.7	8.2	0
7th	November 26—December 2	23·8	8·9	0
8th	December 3—December 9	24·2	8·0	0
9th	December 10—December 16	24·1	7·2	0
10th	December 17—December 23	22·3	4·5	0
11th	December 24—December 31	21·0	3·3	0
12th	January 1—January 7	22·6	4·5	0
13th	January 8—January 14	20·1	4·9	13·2
14th	January 15—January 21	18·5	7·2	37·8
15th	January 22—January 28	18·9	3·5	0
16th	January 29—February 4	23·3	7·2	0
17th	February 5—February 11	25·1	8·5	0
18th	February 12—February 18	28·1	10·1	0
19th	February 19—February 25	27·9	8·0	0
20th	February 26—March 4	29·5	9·7	0
21st	March 5—March 11	26·1	12·7	27·7
22nd	March 12—March 18	26·9	13·5	30·9
23rd	March 19—March 25	25·7	9·8	3·8
24th	March 26—April 1	30·5	14·1	0

(II) FERTILIZING

Total compost, organic manures and chemical fertilizers applied per acre were as follows :

For the basic fertilization, 100 maunds of compost, 41 maunds of bone meal, 49·2 lb. of ammonium sulphate and 24·6 lb. of superphosphate were applied to the field on the same day of sowing (October 21, 1959).

On November 22, 1959, that is, after interculture and weeding was over, supplementary application of fertilizers was made with 114·8 lb. of ammonium sulphate and 57·4 lb. of superphosphate.

(III) INTERCULTURE AND WEEDING

Interculture and weeding was given on November 15, with a hoe. By this operation we could (a) level the field ; (b) pulverize the clods and soften the soil surface to improve water-retention and to promote decomposition ; (c) eliminate weeds. More concretely speaking, the surface of the field must be levelled and evenness maintained as the original harrowing and ground levelling at the time of sowing will not be enough. Large-sized clods nearer to the roots of the wheat plants will have to be pulverized and the ridges maintained in good condition.

No sooner the wheat begins sprouting, the weeds also start growing. Interculture-*cum*-weeding while the weeds are still young and tender will bring good results.

(IV) EARTHING-UP

Earthing up the roots of wheat was done on November 26, 1959. This was done by covering the roots by spreading a two-inch thick layer of surface soil within one foot distance from the roots. Protection of the roots is the main purpose. Many a roots may dry up and die out if are exposed to air or thinly covered by earth. Earthing-up also promotes off-shooting of the roots and is very important in the warmer regions where off-shooting of roots takes place sooner than in cooler regions.

Earthing-up is most timely when the seedlings have four leaves and show signs of rooting. Its effects are noteworthy where the sowing is rather thin and early on a highly fertile soil or where ample manures and fertilizers are applied.

Summary of Operations

Procedural records of our wheat cultivation are summarised as follows :

Variety : *No.* 591

Harrowing	:	October	18	1959
Sowing	:	October	21	1959
Fertilizer application (basic)	:	October	21	1959
Interculture and weeding	:	November	15	1959
Fertilizer application (supplementary)	:	November	22	1959
Earthing-up (first round)	:	November	26	1959
Earthing-up (second round)	:	December	3	1959
Spraying of insecticides	:	December	15	1959
Harvesting	:	March	30	1960
Threshing	:	April	10	1960

Yield : 25 *maunds*

Important Operational Aspects

Acre-wise description of our operations in wheat cultivation with variety *No.* 591 is as follows :

(I) PLOUGHING AND HARROWING

(a) The land used for the purpose had been utilized for paddy cultivation as is explained in the previous part. We started ploughing/harrowing this land by the help of Kubota cultivator (power-driven).

(b) 20 seers of seeds were sown (one seer equals to 2·057 b.)

(c) Five waterings or irrigations were given as follows :

First : from November 2 to November 8, 1959 from the canal.

Second : from December 7 to December 13, 1959.

Third : from December 28 to December 31, 1959.

Fourth : from January 1 to January 3, 1960.

Fifth : from February 15 to February 21, 1960.

(III) METHOD OF SOWING

In our experiment, we had the distance between hills 23 inches and inbetween hills we planted peas for green manure. We obtained a yield of six maunds of peas and three maunds of green manure seed.

(IV) HARVESTING

The best time for harvesting wheat is when the ears and necks of wheat turn yellowish in colour and the colour of the stems and leaves also changes from green to yellow; at this time the grains will maintain hardness like that of wax.

(V) THRESHING

Threshing was done according to the local method.

(VI) YIELD

Wheat	25 maunds per acre
Peas	6 maunds per acre
Green manure	3 maunds per acre

The figure of 25 maunds of wheat per acre is comparable to the average yield in the neighbourhood but it is to be remembered that this much yield was the result of inter-cropping of peas and green manure with wheat. And this inter-cropping, which actually resulted in less yield of the wheat crop was judged unavoidable to secure sufficient supply of organic manures required to carry on a rotation of 3 crops pattern (paddy-wheat-paddy) for years in continuation without bringing diminishing returns.

Cost Analysis of Wheat Cultivation

Item	Quality	Value (Rupees)	Remarks
Seeds	20 seers	8·00	
Manures and fertilizers			
Compost . . .	100 maunds	23·00	
Bone meal . . .	41 lb.	12·50	
Ammonium sulph. . .	164 ,,	30·00	
Superphosphate . .	82 ,,	11·00	
Insecticides . . .	30 ,,	4·50	BHC Pulv.
Irrigation . . .	..	14·00	Water charges.

(V) DISEASE AND PEST CONTROL

Effected on February 15, 1960. A calm, windless day was selected for this purpose. BHC (3 per cent) 30 lb. was sprayed against pests.

(VI) HARVESTING

Done on March 30, 1960.

(VII) THRESHING

Done on April 10, 1960.

(VIII) YIELD

25 maunds of wheat per acre.

Observations on Operations

(I) PREPARATIONS FOR SOWING

Only pure seeds possessing stout potentiality of germination and growth and unaffected by disease must be selected for sowing. Disinfection of them is also necessary. Usually, heavy and large-sized seeds have a higher potentiality for germination and healthy after-growth due to larger germ (embryo bud) and more albumen.

It is important to procure seeds from a reliable source, winnow them for a couple of times on the winnower to exclude impurities and wastegrains, then, discard under-sized grains through a sieve and finally select the good ones by the gravity method (putting the seeds into 20kg. of water containing 4 kg. of salt and taking away those floating on the surface).

(II) SOWING

To ensure quickest and, possibly, simultaneous germination of the seeds, we adopt hot bathing method before sowing them. We prepare a bucket (preferably wooden) filled with hot water whose temperature will have to be kept at the level of 43°C or 111-112° F. Care is required to keep boiling water ready separately and adjust the temperature of the bucket water by pouring into it the additional boiling water because cold seeds in the sack thrown into the bucket will inevitably bring down the temperature of the bucket water. In this case, keep a little opening between the bucket and its lid so that the hot water will gradually cool down overnight.

Try this method in the evening and in the following morning (soaking period : 7 to 10 hours), take the seeds out of the water and dry them in shade. They are now ready for sowing. At this time, the seeds will look whitish at the budding points but no roots will come out. Such delicate seeds should be covered by soft soil well mixed with compost.

CHAPTER II

EXPERIMENT ON BI-ANNUAL PADDY CULTIVATION

Significance

In the region where we are operating, people have not tried second cropping of paddy. It struck us, however, that from both labour-utilisation-*cum*-allocation point-of-view (during slack season) and land utilization point-of-view (better utilization of limited land), bi-annual cultivation of paddy was worth trying.

After a considerable technical study of the feasibility of bi-annual cultivation of paddy in Saharanpur district, we came to realise that, out of so many other reasons, two particular factors were responsible for not growing the second paddy crop among the local farmers. The one was the necessity for an increased supply of organic manures and the other, an adequate supply of water during spring season.

We were of the opinion that the former could have been solved by inter-cropping of green manures and the latter, through construction of canals. However, the limited facilities for canal irrigation might not allow bi-annual paddy cultivation on rather an extensive area but the area conveniently situated for irrigation facilities could beneficially be tried with second cropping in paddy. (Eventually, our present experiment was conducted under well irrigation.)

Thereupon, we chalked out the following Work Programme

(I) Paddy : CH. 4 (Early ripening variety) . . Harvesting Oct., 16

(II) Wheat : No. 591 (Ordinary variety) . . Sowing Oct.,21 Harvesting Mar., 30

(III) Paddy : CH. 4 (Early ripening variety) . . Transplanting Apr., 24 Harvesting Jul., 6

(IV) Paddy : CH.4 (Early ripening variety) . . Transplanting Jul., 15 Harvesting Nov.

Results of (I) above were given in the first part and those of (II) above have been given in Chapter I of this part. This Chapter will, therefore, be devoted to record the outcome of our experiment in (III) above.

Item	Quality	Value (Rupees)	Remarks
Fuel Heavy Oil . . .	1 gallon	2·50	Ploughing/harrowing by tractor for 8 hours.
Mobil Oil	1/10 gallon	0·80	
Canal depreciation. . .	..	12·00	Rs. 150 to be depreciated within 25 years. Repairing cost Rs. 6.
Labour and animal cost			
Ploughing and harrowing	2 heads	3·00	16 hours work
Fertilizer application .	2 ,,	3·00	16 ,, ,,
Sowing	5 ,,	7·50	40 ,, ,,
Interculture and weeding .	3 ,,	4·50	24 ,, ,,
Earthingup . . .	6 ,,	9·00	48 ,, ,,
Pest control . . .	1 head	1·50	8 ,, ,,
Irrigation . . .	3 heads	4·50	24 ,, ,,
Harvesting and transport . .	10 ,,	15·00	80 ,, ,,
Threshing . . .	2 ,,	3·00	16 ,, ,, incl. 2 bullocks
	TOTAL .	169·30	

Profit Calculation of Wheat Cultivation

Description	Unit price	Quantity	Value
	Rs.		Rs.
Wheat grain harvested . . .	17·00	25 maunds	425·00
Wheat straw	3·00	20·5 ,,	61·50
Gross proceeds			486·50
Minus cost of production . .			169·30
NET PROFIT PER ACRE			317·20

Transplanting	April 24, 1960
Fertilizer application (first round)	April 23, 1960
Fertilizer application (second round)	May 7, 1960
Interculture and weeding (first round)	May 7, 1960
Interculture and weeding (second round)	May 10, 1960
Spraying of insecticides	..
Irrigation	..
Harvesting and transport	July 6, 1960
Threshing and winnowing	July 10, 1960

Important Operational Aspects

(I) NURSERY-BED

(a) *Quantity of seed sown.* 10 seers.

(b) *Charred rice-husk* was spread on the nursery-bed, immediately after sowing, to a thickness of half an inch. This was done to (1) attract and absorb sun-rays, (2) protect seeds from birds and insects and also (3) to make uprooting of seedlings easier at the time of transplantation.

(c) *Nursing period.* Forty-Seven days from March 6 to April 24 Young seedlings ready for transplantation had two to three shoots and were seven to ten inches high.

(d) *Fertilizing.* Five pounds of ammonium sulphate and ten pounds of superphosphate were applied five days prior to transplantation. No basic fertilizers (manures) were given to the nursery-bed as the p'ot which was used as nursery-bed had been previously planted with onions and was believed to have retained enough fertility.

(II) MAIN FIELD

(a) The main field had been employed for wheat cultivation. It gave a yield of 33 maunds 9 seers. The first round of harrowing was done on April 4, 1960 and the second round on April 23.

(b) Transplanting was done on April 24 at two seedlings per hill, by the square method, 10 inches × 10 inches, 51 hills per *tsubo* (35·6 square feet).

(c) *Fertilizer application.* Basic, 50 maunds of compost, 41 maunds of sugarcane waste, 75 lb. of ammonium sulphate and 50 lb. of superphosphate were spread on the main field on April 22 and well mingled into the soil through ploughing on April 23, 1960.

Temperature and Precipitation during Second Paddy Cultivation Period

Temperature and precipitation (rainfall) during March 5 and July 8, 1960 was as follows :

Week	From—To	Temperature		Rainfall (mm.)
		Max. °C	Min. °C	
1st	Mar 5— Mar 11	26·1	12·7	27·7
2nd	Mar 12—Mar 18	26·9	13·5	30·9
3rd	Mar 19—Mar 25	25·7	9·8	3·8
4th	Mar 26—Apr 1	30·5	14·1	0
5th	Apr 2—Apr 8	29·3	14·1	0
6th	Apr 9—Apr 15	34·4	17·6	0
7th	Apr 16—Apr 22	35·2	19·7	4·6
8th	Apr 23—Apr 29	34·6	15·4	0
9th	Apr 30—May 6	38·8	17·6	0
10th	May 7—May 13	39·3	18·9	0
11th	May 14—May 20	39·6	23·0	0
12th	May 21—May 27	40·6	23·2	0
13th	May 28—June 3	40·7	23·3	0
14th	June 4— June 10	42·2	26·4	0
15th	June 11—June 17	39·3	25·3	31·2
16th	June 18—June 24	39·3	24·3	32·3
17th	June 25—July 1	35·0	24·6	154·4
18th	July 2—July 8	34·3	26·1	6·3

Summary of Operations

Kind of Variety : C.H.4

Preparation of nursery-bed	March 5, 1960
Sowing of nursery-bed	March 6, 1960
Ploughing/harrowing of the field (first round)	April 4, 1960
Ploughing/harrowing of the field (second round)	April 3, 1960

Item	Quantity	Value (Rs.)	Remarks
Fuel			
Irrigation			
Heavy oil	35 gallons	87·50	280 hours
Mobil oil	3½ gallons	28·00	
Ploughing			
Heavy oil	1-1/3 gallons	3·50	10½ hours
Mobil oil	0·1 gallon	0·80	
Threshing			
Heavy oil	1 gallon	2·50	8 hours
Mobil oil	0·1 gallon	0·80	
Labour and animal cost			
Preparation of nursery-bed	4 heads	6·00	32 working hrs
Sowing	1 head	1·50	8 ,,
Ploughing/harrowing of main field	2 men + 2 bullocks	5·50	16 ,,
			12 ,,
Removal of seedlings	4 heads	6·00	32 ,,
Transplantation	8 heads	12·00	64 ,,
Interculture and weeding (twice)	6 heads	9·00	24 hrs. each
Fertilizer application (twice).	2 heads	3·00	8 ,, ,,
Pest control (spraying)	1 head	1·50	8 working hrs.
Irrigation	12 heads	18·00	96 ,, ,,
Harvesting and transport	10 heads	15·00	80 ,, ,,
Threshing	4 heads	6·00	32 ,, ,,
	TOTAL	288·10	

Profit Calculation of Second Paddy Cultivation

Description	Unit Price	Quantity	Value
	Rs.		Rs.
Paddy grains	12·00	51 mds. 35 srs.	622·50
Paddy straw	1·00	76 maunds	76·00
Gross proceeds			698·50
Minus cost of production			288·10
Net profit per acre			410·40

Supplementary. 50 lb. of ammonium sulphate and 30 lb. of superphosphate were applied on May 7, 1960, after interculture and weeding, to promote ear-formation. Additional dosage (25 lb. of ammonium sulphate and 20 lb. of superphosphate) was given to remedy possible unevenness of fertilizer application on the previous occasion.

(d) *Interculture and weeding* :

First round on May 7 (along the length) and second round on May 10, 1960 (along the side) by using a weeder.

(e) *Harvesting*. July 6, 1960.

(f) *Threshing and winnowing*. July 10, 1960.

(g) *Yield per acre*. 51 maunds 35 seers.

(III) PROCESS OF OFF-SHOOTING AND GROWTH

Date	4 May	14 May	24 May	3 June	13 June	23 June	3 July
Off-shoots (in number)	8·1	13·2	20·7	22·6	20·3	18·7	18·2
Height (in centimetres)	38·7	46·8	63·1	86·9	101·3	111·4	110·8

NOTES. a.—Date of transplantation : April 24, 1960;

b.—Two seedlings per hill, height of seedlings averaging at 20 cm;

c.—The above figures are the means of seedlings collected at 10 sampling plots.

Cost Analysis of Second Paddy Cultivation

Item	Quantity	Value (Rs.)	Remarks
Seeds	12 seers	5·00	
Manures and fertilizers			
Compost	50 maunds	11·50	
Ammonium sulphate	150 lb.	26·00	
Superphosphate	100 lb.	13·00	
Sugarcane waste	41 maunds	7·50	
Insecticides	30 lb.	4·50	BHC pulv.
Irrigation		14·00	Water charges.

As has been explained in the above, the present experiment was made on a plot of 1/5 acre and the acre-wise yield was estimated by the following formula :

Variety :—C.H.4 (early ripening variety)

No. of Field :—No. 1

Area sown :—1/5 acre

Yield from the above :—10 maunds 15 seers

Yield estimate per acre :—51 maunds 35 seers

CHAPTER III

CONCLUDING REMARKS

Successive utilization of a given field for cultivation of paddy-wheat-paddy within a single year and its rotation in the following year has been successfully undertaken. (As for paddy cultivation immediately after harvesting the second crop in the previous year, a detailed report will be submitted soon after harvesting the current crop, from mid-July to end-October 1960.)

The estimated yield of the first paddy cultivation in 1960 (now standing) is 80 maunds per acre provided no unexpected natural calamity occurs and this will be enough to dispel any anxiety if continuous and very intensive utilization of the land might result at diminishing returns in the succeeding crops.

Perhaps, another important feature of our experiment on second paddy cultivation would be a successful employment of the plough drawn by only one bullock. In the place of the traditional Indian plough drawn by a pair of bullocks, an improved Japanese type plough drawn by a single bullock was used with good results. Training of the bullock was also completed within a week's time. The reason why a single bullock could work efficiently with the Japanese type plough was ascertained as due to less resistance attributable to the Japanese type plough compared to the traditional Indian plough drawn by two bullocks as follows :

Traditional Indian plough	520 lb. at 3″—4″ depth
Japanese plough	280 lb. at 3″—4″ depth

The above difference in resistance will naturally increase corresponding to an increase in the depth of ploughing.

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