Origin Plan and Progress of the Sakrand Agriculture Research Station Sind 1927 (1927)

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THE ORIGIN PLAN AND PROGRESS OF THE SAKRAND AGRICILTURALRESEARCH STATION, SIND.

With the adoption of the Sukkur Barrage Scheme and the enormous increase in the irrigated area in Sind which will result from its completion, a whole series of new agricultural problems will arise in the province, the solution of which cannot be certain from what has hitherto taken place either in India or in any other part of the world. This was anticipated from the beginning, and will apply to almost every part of the area which is expected to be commanded by perennial water. But the area in which the results of the application of such perennial water are most uncertain is that very large portion of Central Sind, hitherto either receiving no water at all, or receiving water in the inundation season only, mostly by lift from canals or their branches.

While, therefore, it has been felt that investigations into the agricultural results of the application of peren-nial irrigation water, and the methods required to make this a success,—are needed in every section of Sind which will receive the new supplies of water, yet the most urgent need seems to be in this very large area, supplied from the Rohri canals, now under construction, in the Khairpur State, and in the Na wabshah and Hyderabad districts.

The scheme for the utilisation of the water in this area which has been adopted as the basis for the future is known as the "Baker-Lane" Scheme and was issued in its complete form in 1919. It provides for a complete revolution in the agriculture of this area, in at least the following three particulars.

1. Whereas in the past, only about one third of the area, which was in a condition to be cropped, was put under cultivation each year, the new scheme pro-posed that four-fifths (to be accurate, 81 per cent) of the commanded area should be under crop each season. This practically does away with the system of fallows which

are the basis of present agriculture in this part of Sind.

2. Whereas in the past, the supply of water has been limited to the inundation season, and hence only *kharif* crops (i.e. cotton, *bajri, jowar* etc.) have been possible,—it is proposed to put two thirds of the cropped area each year under *rabi* crops (largely wheat) and the remainder only under *kharif* crops.

3. Whereas, hitherto, except near the tails of the canals, the water has been chiefly supplied by lifts worked by camels or bullocks,—in the future the water suplied will be *by flow,* and will be poured direct on to the land.

It may be suggested that what is essentially the same agricultural revolution as is proposed in Sind, has already actually taken place in the Punjab, and that the canal colonies there, working on a system not widely differing from that proposed, are now among the most flourishing parts of India. This is so, but there are a number of matters in which the analogy is by no means perfect, and which may make the Sind problem a more difficult one. These are as follows:—

1. The areas in question in Sind are very much more deltaic than those in the Punjab, that is to say, they have a much more stiff and compact soil, far less easily drained than is the case in the greater part of the Punjab colonies.

2. The areas in question in Sind have subsoil water, sometimes fresh and sometimes salt, already, at a depth of from twenty-five to forty feet, and therefore, it may be far more easily liable to cause water logging of the lower areas, if large quantities of additional water are turned on to the land.

3. The soil throughout is highly impregnated with salt, the quantity being very considerable even in the areas where cultivation is already carried on, and it will not, in the more compact soils, be possible to remove it so easily as in the lighter lands to the north.

4. Experiments made, hitherto, at Mirpurkhas and elsewhere in Sind where perennial water has been available, have suggested that under a system of cropping such as is proposed, the fertility of the land will rapidly decrease,—unless large amounts of manure are available. Such large amounts of manure will only be available if the proposed scheme of cultivation is altered,—and if animal husbandry forms a much larger part of it than has been expected, *or* if recuperating crops like berseem are grown to a much greater extent than is at present proposed, necessitating in many cases *two* crops a year on the land, and not only *one* as is proposed in the Baker Lane Scheme.

It was from considerations such as these that a Committee in Karachi early in 1924, presided over by the then Commissioner in Sind (Mr. J. L. Rieu) recommended the establishment of a first class agricultural research station in this area, where perennial water could be already obtained, and which was in a representative situation,—to examine and investigate, in advance of the supply of water, some of the points already raised, and at the same time try and lay out the methods which will enable this area in the future to be cultivated to the best advantage, having regard to the proposed conditions of water supply. Many difficulties intervened in the carrying out of this recommendation, but the site recommended by the above committee at Sakrand was, ultimately, made available, the land was cleared of jungle and arrangements for a pumped water supply were made in the latter part of 1925 and early part of 1926, and crops were grown in the *kharif* and *rabi* seasons of 1926-27.

The land available for the experimental station at Sakrand forms a tongue of high land adjacent to the Sakrand *dhand* or lake, which being filled with water from the river Indus during the inundation season, normally retains at least a certain amount of water throughout the year, and forms the main source of water

for the contemplated agricultural station. The entrance channel for the water has been improved and a regulator constructed and it was estimated by the Irrigation Department that it would be possible to rely on getting a supply of water from the river in each year by June 1st. In 1926 and again in 1927 this has not been the case, no water being received in the former year until July 15th. This water is then used by pumping, for which two steam engines are provided, each of 14 to 19 B.H.P. The *maximum* lift from the *dhand* to the distributing tank is 38 feet. The water is very soft and is practically free from silt throughout nearly all the year.

As a resource in case the supply of water fails a tube well has been constructed on the station, the boring made being twelve inches in diameter. Water was struck at 29 feet from the surface, and the boring was continued, in sand, to 140 feet. There is now 80 feet of strainer, recuperation is excellent, and a centrifugal pump placed 28 feet below the ground gives a regular supply of 300 gallons of water per minute without difficulty.

The analysis of the *dhand* water and of the tube well water has given figures as follows :—

	Sakrand Dhand Water (29-10-26) Parts per 100,000	*Tube Well water at Sakrand* (30-6-26) Parts per 100,000.
Total solid matter	17.2	43.6
Calcium Carbonate	5.8	22.4
Calcium Sulphate	4.1	...
Magnesium Carbonate	...	3.8
Magnesium Sulphate	3.9	8.5
Magnesium Chloride	0.7	...
Sodium Carbonate	1.9	...
Sodium Sulphate	...	0.7
Sodium Chloride	0.3	4.7

Such is the water supply which will enable us to imitate the conditions as they will prevail under the Sukkur Barrage, in Central Sind. The land itself extends to 234 acres , and is all above the present highest innudation level. A portion has been occasionally cultivated, by lift, from a channel from the Dad canal, and at the highest of the inundation the minimum lift has been about 13 feet. Most of the land, however, has

never or very rarely been cultivated and was covered with somewhat thick jungle, chiefly *kabhar* or *jhar* (*Salvadora*), *kandi* (*Prosopis spicigera*) and *khirir* (*Capparis aphylla*).

The more I see of this land, and compare it with the very large areas of waste land in Central Sind, the more I feel that it is a very typical site, and that methods and crops which succeed here are likely to succeed over very large areas, and the difficulties which arise here are those which are likely to be found in the greater part of the country.

The soil, as almost every where in Central Sind, is a fine alluvial silt. It drains with fair ease, but only slowly. All over, it contains a good deal of salt, and in some parts so much as to make it unfit for growing crops. A careful, though rough, survey puts the proportion of the agricultural station which is too salt to grow crops without special treatment at 29 per cent. It has been suggested that this is higher than is generally found in the waste lands of Central Sind. On this point it is impossible to say,—for no one knows in advance of a regular survey. Unless the presence of salt (*kalar*) is *very* pronounced, it is impossible to judge of its amount or of its importance in any particular area, without an actual analysis, or until irrigation is actually applied. As this is one of the main features determining the value of these waste lands, any system of classifying them without making such analysis leaves out one of the very large elements which determine their fertility.

One point seems very striking. It is nearly always the highest land which is the most salt, and though there are variations almost every yard, yet the lower lands are, in general, those which are most easily brought under regular cultivation. I will return, however, to this point later.

THE BAKER-LANE SCHEME OF IRRIGATION.

Such is the land on which the Baker-Lane scheme of irrigation for the Rohri Canals area is to be tried, and

it is necessary, before going further to describe in somewhat greater detail, the plan which is proposed for cultivation under that scheme.

In Central Sind, every area of land under command of the canals will be divided so that in any year

(a) 19 per cent of the land will be fallow or not under agricultural crops. This includes the land under buildings, roads and channels.

(b) 27 per cent of the land will be under *kharif* crops.

(c) 54 per cent of the land will be under *rabi* crops.

There will be exceptional cases where actual perennial crops will be grown, where fruit will be cultivated, and the like, but over the bulk of the area the above is the general plan.

Thus, except for the area which does not in any year receive water, all the area will be under *one* crop each year,—two thirds being under *rabi* crops and one third under *kharif* crops.

Now, in Sind, as is well known, cultivation is entirely dependent on irrigation water. There is occasional rain, but it cannot and is not taken into account as a serious factor in growing or the maturing of crops. Hence, the water available for irrigation purposes determines both the character and the extent of the cropping. In the present case, the Baker-Lane scheme provides for certain amounts of water for each class of crop. Thus:—

(a) One cubic foot per second of water (one cusec) flowing continually at the outlet from a canal or distributary into a field is supposed to be enough to ripen 50 acres of rice in the given season.

(b) One cubic foot per second of water (one cusec) flowing continuously at the outlet into a field is supposed to be enough to ripen 100 acres of *kharif* crops.

(c) One cubic foot per second of water (one cusec) flowing continuously at the outlet into a field is supposed to be enough to ripen 200 acres of *rabi* crops.

The meaning of this is not perhaps very clear, and I will try and make it more intelligible. If a rice crop is on the ground four months, the amount of water allowed for it will be 56 inches deep spread over for the whole area. This is of course put on in small amounts daily at first, then every second day, and then finally every five days. But the total water it is estimated under the above scheme to require would form a depth of 56 inches over the whole of the land. There is, however, very little rice to be grown under the Baker-Lane scheme in Central Sind. Other *kharif* crops, of which the most important will be cotton, *jowar* and *bajri,* are allowed half the above amount or a depth of 28 inches of water over all the area, again allowing four months for ripening,—while *rabi* crops are supposed to need a depth of 14 inches of water to bring them to maturity.

The scheme I am trying to describe does not specify the amount of this water that should be given at each dressing. Only the total quantity is specified, but in making it the basis of any attempt to judge of cultivation under the Sukkur barrage conditions, I have taken the following as a standard method of application.

1. Rice (4 months crop) 4 inches of water before transplanting, 2 inches on the same day after transplanting, 2 inches on each of the succeeding three days, 2 inches on every alternate day for six days, and thereafter nineteen dressings of 2 inches of water at intervals of five days (total 56 inches). This, of course, excludes entirely the water required for seed beds.
2. Ordinary *Kharif* crops (4 months crop) 4 inches of water for soaking the land before final ploughing, 2 inches before sowing, and 2 inches thereafter at intervals of ten days when needed (total 28 inches).

3. *Rabi* crops (4 months crops) 4 inches of water for soaking the land before final ploughing, 2 inches before sowing, and a further 2 inches at intervals of twenty days when needed (total 14 inches).

The actual method of application is simply arranged to make a standard, against which the necessities of any crop can be compared.

PURPOSE OF THE SAKRAND STATION.

I have thus indicated the kind of land and the amount of water that will be available in Central Sind under the Sukkur barrage scheme, and it would be the purpose of any experimental station that is established in this area to try and obtain reliable information on a series of questions to be answered which were defined by the Committee which sat on the subject early in 1924, as follows:—

1. The best rotation of water to give the maximum duty for the water without damaging the land either by the production of *kalar* (salt) or otherwise. In this connection the use of water for the cultivation of leguminous crops may be emphasized.
2. The best rotation or series of rotations of crops which will enable the maximum returns to be got from the land without damaging it, while at the same time maintaining its fertility.
3. The production of the types of crops which will give the best results and maximum returns under the barrage conditions, especially types of improved cottons, and the methods of ensuring that these shall be grown in the best possible manner.
4. The best way in which the land can be tilled under the new conditions, whether by cattle or otherwise. If by cattle, the chief problem is as to how the necessary fodder for the cattle can well be produced when the

waste land available is largely reduced. If otherwise, then how far can the necessary manuring of the land be done in the absence of cattle or with a largely reduced supply of cattle.

5. The best methods for preventing the development of salt (*kalar*) in the land, the best methods of utilizing land containing a limited amount of salt, and the reclamation of salt land.

It is quite obvious that an extensive programme like this can only gradually be worked up to, especially when the agricultural station where it is to be done has only just been taken out of jungle. Hence in the period under report, attention has been concentrated on three problems which were defined at the end of 1925, as follows :—

1. To determine the crops and types of crops which can best be grown under the conditions which will prevail under the Sukkur Barrage in Central Sind.
2. To determine the rotation of crop and of water which will best suit the circumstances.
3. To study the effect of the watering proposed under the Sukkur barrage on the development of salt.

Now, at the end of a period of work, including one *kharif* and one *rabi* season, and a portion of a second *kharif* season we can say something with regard to the first of these lines of investigation and a little with regard to the other two.

In order to bring the Baker-Lane scheme into operation, it was necessary to divide the area which could be dealt with into three parts, two of which will, when the station is fully developed, be each year under a *rabi* crop and lie unoccupied through the *kharif* season, and one of which will each year be under a *kharif* crop and lie unoccupied in the *rabi* season. Two of these areas, one *kharif* and one *rabi,* have been brought under

cultivation in 1926-27, and the third will be under a *rabi* crop in the season of 1927-28. The land for all these crops, which was very largely under heavy jungle whose removal was necessary, had to be cleared, and fully canalised, so that the water given to any area could be at least approximately determined. It was then ploughed throughout with a motor tractor* to a depth of eight to ten inches before being finally laid out in plots for irrigation, of one-eighth of an acre each.

Beyond this an area of 8½ acres was reserved for special experiments on the effect on the soil and crops of different methods of applying accurately measured quantities of water to the land, especially when the land contains much salt,—but these will be noted later.

Before describing the crops grown, and the conclusions reached, it may be stated that we have rejected all the methods for determining amount of water added to any piece of land, which depend on the use of a notch or module. Such methods are very approximate. Instead of these, we have used two systems. The first and most accurate, is the delivery of a definite measured quantity of water in a tank to a definite measured quantity of land, through a masonry channel. This method which is exclusively used for all experiments to determine the effect of quantity of water either on the soil or on crops, is very accurate and the water added to any piece of land is known within about 0.2 to 0.3 per cent. The other method is to add water delivered by one of our pumps at a known and measured rate for a definite time to a measured amount of land,—through a masonry channel as far as possible and then through an earthen channel for the remainder of the way. The amount added is thus less accurately known than in the former case, but is probably much closer than with any known notch or module.

In order to determine the suitability of land similar to that of which the Sakrand station consists for a

*It may incidentally be noted that the actual running cost per acre of tractor ploughing to this depth, in dry soil, was Rs. 4-9-7 per acre. Counting depreciation, I take it that this ploughing cost Rs. 6-5-4 per acre.

variety of *kharif* crops, with the amount of water arranged in accordance with the Baker-Lane scheme, a large number of such crops were grown on what was largely virgin land in 1926. This put us in some difficulty as a portion of the land was found to be much more *kalar* than had been anticipated either by ourselves or by the surrounding cultivators. This shows how *only* the actual application of irrigation water will often reveal whether land does or does not contain too much salt for the healthy growth of crops. Unfortunately much of the land so affected had been set apart for cotton, but nearly all the other crops were successful with the limited quantities of water used.

KHARIF CROPS OF 1926.

We will now indicate the *kharif* crops which were experimentally and successfully grown with the amount of water used, and any special difficulty met with in each case.

Rice—Two acres of land were laid out for rice, on land which had never, so far as we know borne rice before. The varieties used were from Upper Sind (Larkana), namely *Kangni, Dadkani, Prong,* and *Jajai,* and were grown by transplanting, using selected seed from the Government Farm, Larkana. The watering given was according to the standard laid down (page 7) but as it was transplanted late, it ripened in less than the four months recognized for the crop. Three inches of rain was received during the growth, and the water actually received was thus—

1.	By irrigation	44 inches.
2.	By rain	3 inches.
	Total ...	47 inches.

The seed was sown in seed beds on June 10th, and the plants were transplanted between July 15 and 21st. In transplanting single plants were used.

There were no difficulties in growing this crop with the amount of water indicated, and (on the virgin land) without manure. The crops reaped were as follows :—

Variety.	Yield Per Acre of Grain.
Kangni	1384 lbs. per acre.

Dadkani	1572 lbs. per acre.
Prong	2036 lbs. per acre.
Jajai	1244 lbs. per acre.

These results, though in no way striking in point of yield show that under the conditions of Central Sind, and with less than the water supply provided for under the Baker-Lane scheme the best varieties of Upper Sind rices have grown without difficulty and yielded at least a fair crop. The relative shortness of the crop was, we think, largely due to the delay in sowing and transplant-in,—and possibly, to the quantity of water being smaller than that usually given.

Jowar—Jowar is classed as an ordinary *kharif* crop and hence is entitled to 28 acre-inches of water spread over four months. In the present case, the local *jowar* was used, and was sown on two acres, on July 23 1926, after the preliminary waterings described in the standard system of page . The actual water received by the crop, including the preliminary soaking of the land was as follows:—

1.	By irrigation	15 inches.
2.	By rain	3 inches.
	Total ...	18 inches.

As only 2½ months watering were required (the last dressing being given on October 1, 1926 and the crop reaped on October 21, 1926), the amount of water needed was considerably lower than the standard taken, but the crop never showed any sign of water deficiency.

The *jowar* crop reaped was as follows:—

	Yield Per Acre.	
Variety.	Grain.	Kadbi.
Local *Jowar*	2220 lbs	4800 lbs.

This is recognized as an excellent crop, and showed that under the proposed barrage watering, this crop can be expected to yield first class results, at any rate on virgin land in Central Sind.

Bajri. This crop is the common grain crop in the neighbourhood and is known to grow well. Local *bajri* was used, and thus it became a test as to what yield could

be obtained with the regulated watering of the Baker-Lane scheme, on well prepared land. The crop was sown on August 4th (decidedly late) and reaped on October 24th. The water received during this period was as follows:—

1.	By irrigation	12 inches.
2.	By rain	3 inches.
	Total ...	15 inches.

The crop grew excellently, except for a few small *kalar* patches, and gave a yield as follows:—

1.	*Bajri* Grain per acre	1496 lbs.
2.	*Bajri* kadbi per acre	1700 lbs. dry kadbi and 2125 lbs. semi-dry kadbi equal to a total of 2760 lbs. dry kadbi.

This crop compared with an average of 750 lbs. of grain per acre obtained by surrounding cultivators, on land exactly similar and equally new with the usual methods of cultivation and of lift water from the inundation canals, of which there was an abundant supply.

Maize. Maize is not a common Sind crop, except in areas near Karachi as a fodder, but it seems one which has great possibilities in Sind, with a regulated water supply. Two types were, therefore, grown one from the Deccan, and the other from Gujarat (Panch Mahals) Both were sown on July 23rd and the crop was reaped on November 10 to 12th 1926. The water which the crop received was as follows, 4 inches of irrigation being given before planting and the rest (after the first) at ten days intervals:—

1.	By irrigation	16 acre inches.
2.	By rain	3 acre inches.
	Total ...	19 acre inches.

The Deccan maize grew well, far better than that from Gujarat. The latter was neither tall nor luxuriant. The yield was as follows:—

	Yield of Grain per acre.
Deccan Maize.	1,200 lbs
Gujarat Maize.	430 lbs.

It is clear that this crop needs further investigation and careful selection of the most suitable variety for Sind conditions. Several types of maize including some from the Punjab are being tried in the season of 1927, and it is again obvious that some of these are more suitable than others, but it is equally clear that some of them have great promise for the barrage areas.

Castor. Among the crops which seem to have considerable promise every where, owing to the rapidly increasing demand for castor oil, is castor, and there is a special opportunity in the barrage area in Sind, as the soil is exactly of the kind on which this crop flourishes. The crop is hardly now grown in Sind, except as odd plants and as borders to fields, but one acre was put under castor in 1926, half being grown with seed from the Deccan and half with seed from Gujarat. The whole was sown, by dibbling seed, at three feet apart on August 13 to 16th 1926, and the land was then watered with 4 inches of water. The sowing was very late, but the crop flourished luxuriantly from the beginning. It was watered at first every ten days (2 inches of water at each watering) and afterwards at longer intervals. The total water received by the crop was

(1)	By irrigation.	22 inches.
(2)	By rain.	3 inches.
	Total	25 inches.

The first pods were ripe early in March, and reaping continued (once a fortnight) till the end of April 1927. The yield of clean seed obtained was 810 lbs. per acre with Gujarat castor and 758 lbs. per acre with Deccan castor. This is worth about Rs. 7 per maund in Karachi or Rs. 69 per acre for Gujarat castor and Rs. 64/4 per acre for Deccan castor.

The crop shows promise of being very valuable, as the cost of cultivation was small, only one hoeing being given after the seed was sown, and no watering being required. Further, in 1927 it has proved itself a crop *very resistant to salt in the soil,* flourishing where a number of other crops have refused to grow. At present

the discovery of such crops, which will grow in salt land without requiring excessive amounts of water, is a matter of great importance.

Tobacco. There is a large future for tobacco in Sind when cheap water is available,—for the crop is already grown where well water can be had. On the other hand the cultivation requires a good deal of care and is, at present, in Sind, rather the work of cultivators who make a speciality of the crop. About half an acre of tobacco was grown in 1926, nearly all under local Sind tobacco, but a small area under an improved Gujarat type (Nadiad No. 6). The Sind tobacco grew well in the seed bed, and was transplanted on the sides of ridges between August 12 and 31st 1926. After transplanting it flourished, being watered every ten days, receiving ten such waterings at 2 inches of water every irrigation. The total water given, after transplanting, was

1.	By irrigation	20 inches.
2.	By rain.	3 inches.
	Total	23 inches.

A topdressing of 2 cwts of Sulphate of Ammonia per acre was given in September 1926.

The crop was topped as usual and suckers removed regularly. It was cut on December 21st and cured by the local method. In February 1928 the cured leaf amounted to 1,500 lbs. per acre for which Rs. 13 per maund (of 84 lbs.) were offered, or a value of Rs. 232 per acre. It was, however, kept till June 1927 when the weight had gone down 996 lbs. for which Rs. 17 per maund (of 84 lbs.) were offered or a value of Rs. 201-8-0 per acre.

In the small area devoted to Nadiad tobacco, it was obvious that this was much more delicate than the Sind product and requires much more care in management. The leaves were, however, large, and despite many gaps in the cultivation, it gave 1,000 lbs. of locally cured tobacco in June 1927. There is clearly a probable future for this tobacco in the barrage area,—especially if methods of curing similar to those in use in the Charotar (Gujarat) can be introduced.

Tur or Arhar. Among other crops, not usual in Sind except to a limited extend in the Jamrao area, is *tur or arhar,* perhaps the most popular pulse crop in India. It was decided to test this as a *kharif* crop with controlled water and it was sown on August 7th 1926 in two areas, one with Deccan *tur* and the other with the crop from Gujarat. Both of these flourished well and grew luxuriantly, being drilled on land which had already received a dressing of 4 inches of water. The total amount of water received by the crop was

1.	By irrigation	20 inches.
2.	By rain	3 inches.
	Total	23 inches.

The Gujarat *tur* flowered three weeks earlier than that from the Deccan, namely in the last week in November, while the latter only came into general flower after the middle of December. Locusts attacked the Gujarat crop in places near the end of October, but did not do very material damage. Frost however, occurred early in January and did serious harm, completely ruining the very luxuriant crop on the Gujarat tur which was fast ripening. The Deccan *tur* which had not developed so far, was also badly damaged, but not completely ruined. While in fact, the Gujarat tur gave no crop at all, the Deccan tur produced 534 lbs. of seed per acre, reaped in March 1927. This is small, of course, and represents only about one third of what would have been obtained if frost had not occured, judging from the luxuriance of growth and the amount of flower and pods.

The result shows that we have in *tur* a crop which is a very doubtful one, unless it can be made to ripen early. It flourishes exceedingly, but, being very sensitive to frost is liable to be entirely lost on this account. It is clear in fact, that under Sind conditions a much more rapidly ripening type is needed than those grown in the Deccan or even in Gujarat. The search for such a type must be the next step with this crop.

Sann-Hemp. One of the most vigorously growing crops in the Kharif season at Sakrand has been sann

hemp, a crop now grown to a limited extent in the Bombay Presidency, in the Konkan, the Deccan and the Panch Mahals. If it can be grown well in Sind it may serve three purposes. First it may be a producer of fibre, which is analogous to, but superior to jute, then it may serve as a green manure and so enable land to be recuperated, and lastly it may serve to a limited extent as a very rapidly growing fodder.

In the present case, 80 lbs of Gujarat sann hemp seed per acre was drilled at 12 inches distance between the rows on August 16th 1926. It grew very vigorously from the start and was given water as follows:—

1.	By irrigation	13 inches.
2.	By rain	3 inches.
	Total	16 inches.

It was allowed to ripen and was reaped on December 6, 1926. It gave 1,006 lbs. of seed per acre, and 195 lbs. of retted fibre. The fibre yield was small, but all the staff at Sakrand was new at the retting of it. In the meantime it has been shown and confirmed in the current season, that the crop flourishes exceedingly, is not damaged by any enemy except excess of salt in the land, and may serve several very useful purposes.

Other *kharif* crops which were grown in 1926, need only be referred to. *Til* (Sesamum) began well, but was very late and as it often the case in Sind, it became unhealthy and was attacked by aphis, and, like all the *til* in the districts round, the crop was lost. *Guar* (*Cyamopsis*) grew very luxuriantly, but did not set pods and was cut and used as fodder. As fodder it gave 10400 lbs per acre, with water as follows:—

1.	By irrigation.	12 inches.
2.	By rain.	3 inches.
	Total	15 inches.

This amount of fodder was obtained in nine weeks and represents a very important result. Sweet potato and groundnut were both planted in 1926 on land which turned out to be somewhat salt. But while it is not

possible on this account to give crop yields, it became abundantly clear that both of them would flourish. Hence, they were again planted in 1927 on land known to be free from salt and have grown well and promise, as I write, to give first class crops.

Groundnut was in 1927 sown on the last week of June, and has grown well, particularly after the heavy rain which came a month later, Both 'Spanish Peanut' and 'Big Japan' are being grown, and have so far (September 6th) received water as follows :—

1.	By irrigation.	18 inches.
2.	By rain.	5½ inches.
	Total	23½ inches.

The former variety will require 6 inches more water before reaping, and there is every prospect of a yield of 2000 lbs of dry nuts per acre. So far the only serious enemies we have had are rats, which evidently highly appreciate the plants and the nuts. The crop is however one which is very sensitive to *Kalar* and must be grown on sweet soil. If so grown, it promised to be at least as profitable as cotton as a kharif crop and will occupy the land a much shorter time.

As regards sweet potatoes, the creepers were planted out in good land, with 15 cartloads of farm yard manure per acre, on July 29th 1927. It has done very well, and promises an excellent crop. It is expected to ripen in November. So far (September 6th) it has had water as follows :—

1.	By irrigation.	12 inches.
2.	By rain.	5½ inches.
	Total	17½ inches.

It will require about 12 inches more water before the crop is removed, making a total of 29½ inches.

I wish to refer to one more crop which is to be used partly as a fodder and partly as a pulse crop, namely cowpea or *chavli* (*Vigna catiang*), a crop very rarely seen in Sind except as a vegetable crop near big

cities. In 1926, it was planted on July 23rd at the rate of 20 lbs per acre on land somewhat salt, and gave a crop of green fodder amounting to 9760 lbs per acre (green) on September 20th 1926, having used water as follows :—

water a *rabi* crop on new dry land could be matured. The total water added was as follows:—

1.	Before planting.	4 inches.
2.	During growth. (in three dressings)	6 inches.
	Total	10 inches.

There were 20 cents of rain in January but this may be ignored.

With this quantity of water, considerably below the Baker Land allowance of 14 inches, an average crop of 1100 lbs of grain per acre was reaped in the latter half of March. This included the following varieties.

Phandani wheat (C. P. H. 47) from Upper Sind.	1,281 lbs. per acre.
Awned wheat (G. I. 25)	1,200 lbs. per acre.
Thori wheat (D. I. 38)	1,033 lbs. per acre.
Punjab 11 wheat	1,033 lbs. per acre.
Pusa 12 wheat	792 lbs. per acre.

I do not pretend that these yields represent the capacity of the crop or the land. But they do show what can be done with fresh dry land, with a minimum quantity of water, even with wheat planted late, in Central Sind.

Successful crops of *rabi jambho* were grown on fresh dry land in six inches of water applied by irrigation, but these need no further comment. But the possibilities of land here, may better be indicated by the crops of *berseem* and onions we were able to obtain with definite amounts of water.

Berseem. Berseem is an Egyptian crop which performs two functions,—the first being the improvement of land which has grown cotton or other crop in the previous season and the second the provision of an abundant and very valuable green fodder through the cold weather. It has a third purpose, which is very important with us here, namely to improve land somewhat salt, and make it fit for general cultivation.

The land on which this crop was grown was decidedly salt. Patches proving themselves bad contained 1.05 per cent of total salts in the top six inches of soil. Where the crop flourished normally it contained 0.65 per cent of total salts in the top six inches of soil. These trials were made after the crop had failed or flourished as the case may be.

This land received four inches of water and then the seed was broadcasted on the succeeding day in a further four inches of water, at the rate of 84 lbs of seed per acre on November 21, 1926. This was double the normal amount and equal crops would have been obtained with half the amount. It flourished from the beginning, and a cutting of fodder was obtained on January 11th. Three cuttings were made in all, on January 11th, February 11th and succeeding days, and the last from March 17th onwards. The crop was then left to see if seed would form. Only four cartloads of manure per acre were added before planting.

The total water given to this crop was—

1.	At planting.	8 inches.
2.	During growth.	28 inches.
	Total	36 inches.

And the yield of green fodder obtained was

1st cutting	4,896 lbs. per acre.
2nd cutting	7,440 lbs. per acre.
3rd cutting	10,620 lbs. per acre.
	22,956 lbs. per acre.

Its local value was 6 annas per maund (84 lbs) to be cut by the purchaser—thus giving Rs. 102 per acre without the cost of reaping. As no seed was obtained, which seems to be always the case in Lower Sind, the

I may say that the value of berseem as a crop for improving the soil has been well illustrated this year, for the *jowar* crop grown on these berseem plots in the kharif season of 1927 is excellent.

Onions. Onions are really a garden crop grown in the rabi season, requiring much more water than is allowed under the Baker Lane scheme, but likely to flourish exceedingly in Central Sind if given a chance. At Sakrand, this was planted out on land manured with 15 cartloads of farmyard manure per acre from seed beds on January 15 to 17, 1927 into dry land which was immediately watered with 4 inches of water. The total water added between the planting and May 30th when the crop was reaped, was 24 inches. The crop of onions obtained was, on the average, 15,960 lbs. onions per acre, as sold ten days after taking out of the ground. The greater part of the crop was sold at Re. 1/- per maund of 84 lbs, and the rest at 12 annas per maund bringing in Rs. 164-10-0 per acre. There was no difficulty with the crop whatever.

Potatoes. Potatoes, though they flourished were not so successful as onions, owing to a severe frost which damaged them at the beginning of January. Three types of potato seed were planted, as follows:—

(a) Early Italian Potatoes, planted on November 21st 1926. This received 24 inches of water and was reaped on February 27th 1927, giving 2,800 lbs. per acre. This crop was ruined by frost, but the potatoes obtained were marketable.

(b) Scottish 'Phlo' Potatoes, planted on December 8th 1926. This received 26 inches of water and was reaped on March 25th 1927, giving 5,872 lbs. per acre. This was not badly damaged by frost, and the quality of the produce was excellent.

The manure used for these potatoes was 30 cartloads of farmyard manure per acre, plus sulphate of ammonia at the rate of 56 lbs. per acre as a top dressing after the frost.

Neither of these crops could be counted as good, but the experience has been valuable, and the way the crops were damaged by hedgehogs and other animals has given us an idea as to what there is to fight against.

PERENNIAL CROPS.

It remains to deal with preliminary results concerning two perennial crops whose future is very important in the barrage area, namely lucerne and sugarcane. The former of these seems to have not only great value as a means of reclaiming salt land, but yields very large quantities of fodder, the latter, sugar cane, has a big future if some of the new canes which have been of such very great importance in North Indian can be acclimatised and established in Sind.

Lucerne—The land chosen for lucerne was all more or less salt. The sweeter portion was planted in rows on the flat: the more salt portion was sown between ridges in furrows in which water was allowed to flow. All was put in the last week of December 1926 and the first week of January 1927. It was anticipated that great difficulty would be found in establishing the crop, owing to salt, but the methods adopted were unexpectedly successful and except for a few limited patches, where there was actual salt efflorescence when the soil dried after irrigation, it is proved that lucerne can be used, even as a first crop on land fairly intensely infected with salt.

The seed was planted on the flat in dry soil, and was immediately treated with two inches of water, then one inch after five days, and thereafter two inches after ten days. In the area where lucerne was to be planted in furrows, the whole beds were first soaked with four inches of water, then ridges were made, seed was planted by hand in the furrows, and two inches of water given at once. After this the watering was the same as with the lucerne planted on flats.

The total water given in the two cases up to August 18th 1927 was as follows:—

1. Lucerne planted in beds 52 inches.
2. Lucerne planted in furrows 50 inches.

This was in addition to 5½ inches of rain.

Cuttings commenced from March 2nd, and have continued since then on April 1st and thereafter at intervals of 21 days. Eight cuttings have been taken up to August 18th, and the crop reaped has been as follows :—

1. Hyderabad Lucerne grown on the flat 32,811 lbs. per acre.
2. Hyderabad Lucerne grown in furrows 20,394 lbs. per acre.
3. Poona Lucerne grown on the flat 19,958 lbs. per acre.

To get this, ten cartloads of farmyard manure per acre were given before planting, and after the above cuttings have all been taken, another similar dressing is being given in September 1927.

The chief interest of this lucerne growing is the fact that a very valuable crop can be obtained on fresh land, known to be salt, immediately by the use of the furrow system, and that so far as we can see, when the lucerne has to be dug up in a year or two, the land will be in good condition for any crop whatever. This itself is a very important conclusion.

Sugar cane—After a good deal of discussion, it was decided to try the cultivation of good varieties of sugar cane from North India at Sakrand, with a view to see how far they are suitable for Sind, and in particular how far they can replace the poor reed canes which (except in the neighbourhood of large towns for eating) are the only ones now cultivated in Sind. A number of the new Coimbatore and other canes were obtained from Shahjehanpur (U.P) by the kindness of the Director of Agriculture, U.P. and were received on February 9th. This is not the place to give details as to the method of cultivation adopted, as the crop is now only being grown. But at least one type of Coimbatore cane (Co. 213) shows great promise, and, to me at least, looks as if it could give high yields in the barrage area

in Sind. I cannot say more at present, as it will not be reaped till the end of 1927. So far (February 9 to September 1st 1927) it has had 52 inches of water, in addition to 5½ inches of rain.

IMPROVEMENT OF CROPS.

While one of the primary purposes of the Sakrand station was to see what crops would grow well, and what varieties of these crops would grow best, under irrigation conditions as specified by the Baker-Lane scheme for working the post-barrage water supply, yet almost a matter of equal importance was the working out of specially suitable types of the staple crops for these conditions. In every crop the question arises. Cotton will grow, but what type of cotton will grow best under particular conditions? Wheat can be cultivated,—but will the types which have done best in the Punjab or North India generally, be equally the best under the conditions of Sind,—and so on. Thus it has become important especially where relatively new crops are being introduced in an area, (through not exclusively in such cases) to acclimatise, select and breed types specially suitable for the climate, soil and water arrangements present.

Work on these lines has been actually taken in hand at Sakrand with four of the chief crops to be grown, and on a small scale with a fifth, and it is necessary to give a very short account of the position with these crops.

Cotton—Deshi cotton in Sind, though it has a market of its own, is very inferior, has a short staple, and is very rough. Its chief advantage from the grower's point of view is that in the special type worked out at Mirpurkhas by the Agricultural Department, known as "27 W.N. " it yields highly and has a very high ginning percentage. Wherever the country has to depend on inundation canals, however, this has been the sole cotton which could be grown with success, and it is the standard *deshi* cotton for Sind.

But the coming of canals which give a water supply for a longer period of the year, gives the chance to

Egyptian and American cottons. The former were tried on the Jamrao canal in its earlier days but the varieties then grown proved too sensitive for Sind conditions and its cultivation was abandoned nearly twenty years ago. American cottons have had varying success. Seed of a type known as 'Triumph' was imported on a large scale, and had a success for a number of years, and then it was supposed to have deteriorated and has almost died out. Then Punjab American types were introduced, and the recent development of about 30,000 acres on the Jamrao Canal are almost entirely of the Punjab F. 4, a very medium staple, but very luxuriant American, and to a small extent of Punjab F. 285, a somewhat better but lower ginning type. Neither of these is, however, pure, and this always opens the possibility of deterioration.

Two things are, therefore, to be done at Sakrand. First we have to try a number of the Egyptian and American types and second we have to select from any of these which are promising, those strains which will give the largest crop of high ginning, good staple cotton.

For this reason, in the *Egyptian* types, we have imported five of the well known kinds of cotton seed,—Sakel, Pilion, Boss 111, Zagora, and Ashmouni, and tried to see how far each of them will flourish under the conditions of Central Sind, with, however, a guaranteed water supply. We have used these for nearly two years now, and I think I can say that with the exception of the last (Ashmouni) there is little chance for any of these Egyptian types in Central Sind. Whenever they are planted, whatever be the water supply, they have shown themselves too delicate for the conditions, which involve a far higher temperature during growth than that to which they are accustomed in Egypt. The last (Ashmouni) is in a different case. It comes, as is well known, from Upper Egypt, and though its quality is not equal to the best Egyptian, yet it promises to be healthy and flourish in Sakrand, and to form the basis, after further selection, for it is a mixed type, of an Egyptian cotton which can be successfully grown in Central Sind.

With regard to American cottons, one of the most disappointing series of experiments in the last few years has been the attempt to grow cotton seed directly imported from America in Western India. Everywhere plants from such seed have shown themselves, in most cases, unsuitable. They have not been vigorous, have yielded badly, and have become diseased, in all except a very few cases. And though about forty of the leading American types have been tried in Sind, only one of them is promising, and three others have possibilities of acclimatisation. The promising type is '*Acala*' and this flourishes luxuriantly and flowers well, giving a medium American cotton (just over 1 inch in staple); others which have possibilities are '*Durango, Hartsville*', and '*Delta Type Webber*' which are still under trial. These three, however, are much more likely to become the basis of crosses with more luxuriant Punjab types than to have value on their own account.

The Punjab American cottons are in a different category. They grow luxuriantly and yield well,—but, as in 1926 they are liable to sudden, and, so far, unaccountable failures. The best among them, as far as luxuriance and yield is concerned,—the so called F.4,—is a low grade American cotton. Already improved strains have been isolated from these Punjab cottons, and either these themselves or crosses between them and the better class American cottons bid fair, I think, to become the standard American cottons for Sind in the future.

Wheat—In determining and developing types of wheat suitable for Sind conditions two methods have been followed. Either the kinds of wheat more recently developed in North India have been imported and grown, or else selection has been started in the local 'Phandani' and 'Thori' types grown hitherto in Northern Sind and in awned wheats grown in Lower Sind. Both methods are proving successful in the great wheat growing areas and 'Pusa 12' wheat is now the standard type in Larkana, Sukkur, and Upper Sind Frontier. The selections made from 'Phandani' and 'Thori' are also proving a success in North Sind, and are giving 20 per

cent higher yield than the varieties from which they are selected.

Pusa 12, selected 'Phandani' (C.P.H. 47), 'Thori' (A.T. 38), and awned (G.S. 25) wheats are the basis for the work at Sakrand, and the standards with which selections from wheats already locally grown or imported from elsewhere are to be compared. This comparison is now in hand, and already there are signs that it may be possible to get something even more suitable than any of these for what will be the enormous irrigated wheat area of Central Sind.

Jowar—We have come to the conclusion that, in almost any of the staple crops of India, it is possible to increase the crop by 20 per cent or thereabouts by selecting the best strains in any variety. Such selection is not an easy process and takes a long time. But success seems almost assured if the selection is done skilfully and precautions against later contamination are taken.

In the case of *jowar,* which is likely to be the largest staple *kharif* food crop in Central Sind in future, displacing *bajri* in many areas, we are in the fortunate position of having a fairly large and representative collection of Sind *jowars* grown for a number of years at the Larkana farm, and these are forming the basis of our further selection at Sakrand. The work is of the highest promise. We are able, already, to get an even high yielding crop, to isolate types suited to almost any conditions and, in two or three years, seed will, I think, be available which is specially suited for a considerable number of specified areas. I have rarely seen better *jowars* than those we have been able to grow from selected seed, at the Sakrand station.

Rice—Though the area of rice in Central Sind will, under barrage conditions be limited, yet this crop will be one of the two largest staples on the right bank canals, and will always be used where there is excess of water and where land has to be reclaimed from salt.

Improved types of rice, giving more than 20 per cent improvement in yield over the local rices of the same

class have been developed at Larkana for the rice area of that district of North Sind. These have been successfully introduced at Sakrand and form our standard of comparison with the further selections now being made from rice grown in Nawabshah in Lower Sind, elsewhere. This further selection is now being vigorously pushed.

Guar—Perhaps the standard *kharif* leguminous crop useful as a fodder, as a vegetable, and as a grain crop, in the alluvial soil of Sind is *guar* (*Cyamopsis*) and it has, I feel, a big future. But the crop as grown is a mixture of many types, some of which, as far as we can judge from observations already made, are likely to give double the yield of others. These different types have never, so far as I am aware, been described separated and studied. This work is now in hand on a small scale at Sakrand, and has very great possibilities.

EFFECT OF IRRIGATION ON SOIL.

The introduction of perennial water,—or rather of water which can be available, if wanted, at any time of the year,—will have some effect on the soil to which it is applied. What will this effect be? So far we can only judge from what has happened in other countries, but none of these are really comparable with the areas of Sind to which such water is to be introduced. Will it cause a very large development of salt in the land? Will the land rapidly lose in fertility? Will it be possible to clear the very large areas of salt land among the waste areas of Sind, and bring them under successful cultivation? Is there danger of water logging by the application of water as proposed under the barrage scheme? These are questions which all those interested in Sind are asking, but to which there is as yet no reply, and cannot be any reply until several years of experiments have been carried out. Such experiments form one of the very large sections of the work at Sakrand and are already in hand in many directions.

Some of the lines of investigation may be noted, most of which demand accurate means of determining

the water applied to the land, which it has never hitherto been possible to get.

1. Experiments are in hand to determine what is the penetration of different doses of water and their effect on the distribution of the salt which occurs in such a large proportion of the Sind soil. If the salt is washed down to a definite depth will it rise again if the soil becomes dry? and what is the depth to which it must be washed to prevent the possibility of its rising again?
2. Experiments are also in hand to determine the extent to which each of the probable staple Sind crops will stand salt of the composition usual in Sind, and so to determine the crops likely to be most suitable at every stage of salt reclamation. This is important because it is becoming clear that the definitely salt areas in the waste lands of Sind,—and especially among the higher lands,—are far more numerous and greater in extent than is generally supposed.
3. Experiments are also in hand to see how far the subsoil water level will be affected by the type of irrigation proposed under the barrage arrangements. It will only be possible to get results slowly, but the matter is important.
4. Experiments are in hand too, to determine how, accepting the Baker-Lane scheme of water distribution as a basis, the water should be applied, to get the best results. Already for example, there is distinct evidence that for *jowar, guar* and cotton as *Kharif* crops, it is better (provided there is a thorough preliminary soaking of the land) to give larger dressings of water at longer intervals than smaller dressings at shorter intervals. But the work is only at the preliminary stage, and will demand both time and patience.

5. Experiments are already in hand to try one method at least by which salt can be rapidly either removed from land or rendered innocuous. This is by the use of Calcium Chloride and it appears to have some promise.

6. Experiments will shortly be in hand to determine the loss of fertility which takes place by continued cropping of the same land with the same or with different crop. Past experience in Sind (Mirpurkhas) is that wheat grown on the same land in successive *rabi* seasons, rapidly gave a very small yield. But this matter will now be tested on a larger scale and under bigger variety of conditions. Such cultivation, as is well known, causes loss of condition in the soil, and it is important to see how tilth can be maintained in these circumstances.

These are just a few of the sort of problem which we have in hand, and on whose solution the success of the post barrage cultivation largely depends. Time only can tell how far solutions can be worked out.

THE USE OF TRACTOR CULTIVATION IN CENTRAL SIND.

Incidental to the inquiries which have been and are being made as recorded above, the question of the method of cultivation to be adopted on the huge areas which will come into use under the Sukkur barrage canals must be considered. It is quite clear that the cattle in Sind are not sufficient to cultivate the area, and if cattle are imported from the surrounding tracts of Rajputana, Baluchistan etc., it will mean the devotion of a very large area to the growing of non-remunerative fodder crops. This is particularly the case, because the present fodder resources of Sind largely consist of wild trees and shrubs,—most notably the *kandi* (*Prosopis spicigera*) and the *babul* (*Acacia arabica*),—and when the barrage areas come under cultivation these will be largely removed and the present fodder supply very materially

curtailed. The question, therefore, arises as to how far mechanical cultivation by motor or otherwise can replace bullock power, and it is one which is obviously of very great importance, and one which will be investigated in detail at Sakrand. At present I can only present some provisional, but, I think, important results.

In the first place it must be remembered that neither in Sind or anywhere else can mechanical cultivation completely replace work by animal power. The best results obtained in the United States in areas where tractors are used to a greater extent than almost anywhere else, indicate that they may replace about 36 to 40 per cent of the animal power on a farm, but not much more than this. That is to say that if a farm requires eight pairs of bullocks for its efficient working, this number can be reduced to five pairs if a tractor is used, but probably not to a much greater extent than this,—and this fact must be kept in mind in considering tractor cultivation as a means of dealing with the barrage area in Sind.

Secondly, the unit of cultivation must be large. It is no use trying to cultivate fields of one acre or less which are usual in almost all the irrigated areas of Sind—with a motor tractor. If they are to be cultivated in this manner, a number of such fields must be thrown together, bunds broken down, and the combined area cultivated as one field. Our experience at Sakrand seems to indicate that a field of four acres is about the smallest unit for economical cultivation.

Thirdly,—and this is important in Central Sind,—the land must be thoroughly cleared of woody jungle both above and below ground. Under the method of cultivation hitherto followed, where land is used for crops once in three years or more, it has never paid really to clear the jungle, which has been simply cut down when the time for cultivation arrived and allowed to grow again in the period between the years when the land is used. The result is that most of the areas consist of more or less scrub jungle above ground, but of a mass of thick interlacing roots underground, in

patches, which cannot be removed by any known method of stump-pulling or burning, but which must be dug out laboriously by hand. At the Sakrand station the removal of such jungle and roots has cost Rs. 55 per acre and I doubt whether it can be done for less over very large areas in Central Sind. But the removal of the jungle and especially of these roots is necessary before the land can be properly developed, and especially before cultivation by motor can be undertaken. If it is not done, constant breakages of implements will be found for though there are certain implements on the market for ploughing land of very hard and bad character,—notably the so called brush-breaker'—yet even these implements will not face the opening up of land such as that under consideration in Central Sind, unless the greater part of such root jungle as I have described is first removed. Even after digging out the jungle, the probability of breakages on account of such roots which may remain must be faced. In our own case at Sakrand, after spending Rs. 55 per acre for clearing, the three-bottom plough used with the motor tractor broke down within a week of beginning the opening up of the land with it, causing a week's delay and the cost of replacing broken parts.

But, if these conditions be recognized, then there seems a very great field for the use of motor tractor ploughing in opening up new land in Sind, and in doing the very necessary dry ploughing to allow the soil to weather fully between crops. The experience at Sakrand, with a typical somewhat heavy silt soil, in opening up new land, has been obtained with an 'International' 15/30 motor tractor working with (1) a three furrow, 12 inch mould board plough and (2) a four furrow, 24 inch disc plough.

In careful tests on opening new land conducted by Mr. R. M. Tambe, Assistant Agricultural Engineer in Sind, on units of not less than four acres the following results were obtained.

I. International tractor, 15/30 H.P. and three furrow, 12 mould board plough, ploughing 8 to 10 inches deep.

(a) Total area ploughed 46 acres 27 gunthas.
(b) Total number of hours worked 66 hours 10 minutes.
(c) Cost of fuel, lubricants and sundries Rs. 192-11-0
(d) Drivers and Cooly wages for the days on which the tractor worked Rs. 28-0-0.
(e). Actual cost of ploughing one acre Rs. 4-9-7.

This cost does not include supervision, depreciation, interest and repairs. If these charges be put at 30 per cent on the investment, per annum, the cost, including them, would be Rs. 6-5-4 per acre, on the understanding that the tractor and plough does four to five acres per day. In the above test 5.6 acres were done per day of eight working hours, but counting stoppages it is not safe to assume more than five acres per day of eight working hours.

II. International tractor, 15/30 H.P. and four furrow, 24 inch disc plough, ploughing 8 to 10 inches deep.

(a) Total area ploughed 19 acres 30 gunthas
(b) Total number of hours worked 48 hours.
(c) Cost of fuel, lubricants etc. Rs. 99-1-0.
(d) Drivers and Cooly wages Rs. 14-6-6
(e) Cost of ploughing one acre Rs. 5-12-0

This implement—the disc plough,—proved not nearly so efficient for opening up new land of the Central Sind type as the mould board plough, though it might be valuable for heavier and harder land. In the Sakrand land, it tended to sink and bury itself frequently, and so very much time was lost. Counting the same amount for depreciation, supervision, interest and repairs per acre as in the previous case, the cost per acre opened up by ploughing in the manner described would be Rs. 7-7-9.

These results are, of course, preliminary, but I record them because there is a demand for immediate information on the points discussed. The results would probably not be widely different with any modern efficient type of motor tractor.

CONCLUSIONS.

I have endeavoured in this bulletin to give some idea of the agricultural conditions under which it is proposed to develop the land under the Sukkur barrage in Central Sind and of some of the problems which *must* be settled before the development takes place, if the best results are to be obtained and disasters avoided. The Sakrand Agricultural Research Station is intended to experiment in connection with these problems, with a view to having the information available when the barrage water becomes available. We have, in fact, established a station where the barrage conditions can be reproduced now, almost (though not quite) in their entirety, on land typical of enormous areas in the country, and a few of the preliminary results are here indicated. Time only can lead the clearing up of the problems set out in previous pages, but enough has been indicated to show that there is reason to suppose that before the barrage water becomes available in four or five years' time it will be possible to determine how best the land should be opened out, what crops and rotations will give the best returns, how salt land can best be dealt with, what water will be needed by the crops grown and how best it can be applied, what varieties of each crop will give the best results, and how the land coming under the barrage can be protected from deterioration and from diminution in the returns. By its capacity to answer these questions before the development of the new irrigation in Sind, the success of the Sakrand Station will be judged.