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Department of Agriculture, Bombay.

BULLETIN No. 64 (OF 1914.

ALKALI OR KALAR EXPERIMENTS AND COMPLETION REPORT OF THE DAULATPUR RECLAMATION STATION, SIND.

G. S. HENDERSON, Deputy Director of Agriculture, Sind.



BOMBAY PRINTED AT THE GOVERNMENT CENTRAL PRESS 1915

PLATE No. 1



A Field of Berseem. (Frontispiece).

ALKALI OR "KALAR" EXPERIMENTS

AND

COMPLETION REPORT OF DAULATPUR RECLAMATION STATION IN SIND.

CHAPTER I.

Alkali or 'kalar' is a condition occurring in arid or semi-arid districts in all parts of the world. The 'alkali salts' giving rise to this condition are formed naturally by the decomposition of the soil forming materials and in ordinary circumstances are removed from the soil by the rainfall. With a small precipitation the products of decomposition are not removed but tend to accumulate in the surface soil. It is useful to divide the different classes of alkali land as follows :---

- I. Naturally saline and arid with deep sub-soil water.
- II. Naturally saline and arid with sub-soil water near surface.
- III. Made saline through artificial causes possibly by seepage or percolation water.
- IV. Salt land with fair rainfall but high sub-soil water.

As salt lands occur in so many parts of the world it is important to distinguish the class to which they belong before taking steps to ameliorate their condition. Irrigation has often been blamed for bringing alkali on to newly cultivated lands; except in case of III above, however, it has only the effect of accumulating the alkali on the surface. On irrigation such as that for dry crops, the water first penetrates the soil, the surface water is evaporated on top and more is drawn up from beneath, bringing up dissolved salts which are deposited on the surface. The depth from which water can be lifted and the rate of its rise depends on several factors and especially on the size of soil particles. When the sub-soil water or water-table is within reach of this capillary action, say, at a depth of 2 feet, that is class II, then all efforts of dealing with this class of land are quite useless without first lowering the level of the water table. Accumulation of alkali will be found where there is much evaporation and little or no irrigation or drainage to wash back the salts into the soil, e. g., a village site surrounded by rice cultivation.

A 25-1

Alkali is generally referred to as either black or white according as sodium carbonate is present in quantity or not. According to American investigations the quantities of those substances rendering the growth of plants impossible is as follows:—

23 per cent. of sodium carbonate in the surface soil entirely prevented germination of crop seeds (Bulletin 22, New Mexico Experiment Station).

In soils not containing sodium carbonate '50 per cent. of alkali is given (Report 24, U. S. Department of Agriculture) as the maximum limit for ordinary crops; with this amount growth was uncertain and light. Common salt, sodium chloride seems to be the most injurious constituent of white alkali.

Alkali, however, is generally very local; in the same area there will be patches showing strong alkali and a foot away the land is good. To get an average figure from analyses in this case is very difficult. The growth of a test crop such as berseem is a good index; from the state of crop, experience will tell what the character of the land is.

In report No. 71 of the United States Department of Agriculture it is shown that in water culture experiments plants were stimulated by weak solutions of alkali salts. It is probably on this fact that the practice of applying kalar soil to good land as a manure rests. This is constantly done in Sind, applications of 5-6 tons per acre being often given. The same is also done in Egypt.

CHAPTER II.

Reclamation of salt lands.

The principle underlying reclamation is removing the injurious excess of saline salts in solution in water. In addition in case II the level of the sub-soil water must be reduced and in III the cause of the damage must be remedied.

Where sodium carbonate is in excess much good can be done by the application of gypsum to the soil. This should be applied in an amount exceeding that of the carbonate present. This will be dissolved by the rain or irrigation water and on contact with the carbonate the latter will be converted into the less harmful sulphate. The sulphate, common salt and the other constituents must be dissolved out. Other methods such as scraping off the white efflorescence in the surface soil, mixing with sweet soil, cultivation of salt weeds and other special crops are temporary expedients; they might be useful where the alkali content is small but the same result might be obtained by cheaper means.

From American experiments in California the following table illustrates the per cent. of alkali borne by grain crops :---

	Cara	Ì	Condition		Per cent. in soil.							
	стор. 				Sulphate.	Carbonate.	Chloride.	Total.				
Wheat Do. Do.	 	• ••• •••	Good Dead Very poor	 	°089 °144 °289	-005 -026 -002	'007 '034 '054	-101 -204 -345				

In America no work of reclamation by drainage on a large scale has been carried out but very good results have been obtained in Egypt. The reclamation of the old site of Lake Aboukir is a good case in point. An area of about 30,000 acres has been successfully and profitably reclaimed by an English Company. The soil of the lake is a heavy dense sticky clay and very impervious to water. The average per cent. of the soluble salts in the surface 3 feet of soil was about 8 5 per cent. In the words of the United States American Bureau of Soils Officer sent to report on the work 'the whole aspect of the land is one of utter hopelessness and none but the most sanguine of agricultural engineers would have undertaken its reclamation'. The following are the analysis :---

			ļ	I.	II.	III.
Containing per cent. solubl	e salts			10.24	9.01	5.80
Calcium sulphate				40:10	0'12	4.80
chloride	•••	•••		2.77	912	4 0 9
Magnesium sulphate				-//		
" chloride						
Potassium chloride				3.13	4'72	4.00
" bi-carbonate						
Sodium chloride	•••			44.23	76'18	79'71
,, sulphate		•••			8.70	7.89
" bi carbonate	•••	•••	•••	.77	1.58	2.55

These are exceedingly high, per cent. and exclude any possibility of vegetable growth.

		Organic matter.	Gravel 2 to 1 M. M.	Coarse sand 1 to 5 M. M.	Medium sand '5 to '25 M. M.	Fine sand 25 to 1 M. M.	Very fine sand '1 to '05 M. M.	Silt [.] 05 to [.] 005 M. M.	Clay '005 to '0001. M, M.
I.	Loam	 .65	.52	.40	-38	18 [.] 42	35 [.] 66	28 [.] 46	16 [.] 16
11.	Black Clay	•92	14	1.76	1-24	2 [.] 24	6 [.] 38	11'96	75 [.] 82

The mechanical analyses of the soil samples is as follows :----

An important fact is brought out here that for example the last analysis is misleading; according to the mechanical analysis it should have been an almost impervious clay soil but it was actually easily drained, perfectly amenable to cultivation and favourable to plant growth. It was found in actual practice all these saline soils are much more pervious to water than would appear from laboratory inspection owing to the aggregation of particles by the cementing action of lime and magnesium carbonates.

Aboukir land lies below the level of the sea so the drainage had to be pumped in order to lower the level of the sub-soil water. The land was canalised, levelled, washed and cropped as mentioned in detail on the Daulatpur Reclamation station.

CHAPTER III.

Alkali Conditions in Sind.

In arid America, field parties of the Bureau of soils have mapped the soil and studied the alkali conditions of a number of typical irrigated districts covering over 3,000,000 acres of land. They have found that on the average about 13 per cent. of the irrigated lands examined contain alkali in sufficient quantities to be either harmful to the growth of crops or to prevent entirely profitable cultivation. Sind has 30,000,000 acres, half of which are scheduled as cultivable and 4,000,000 are cultivated annually under irrigation. It is not possible to say what the per cent. is in Sind of alkali or kalar land without a proper soil survey but it would probably be found not to be under the above percentage.

In 1906 the Government of India called for report from experienced local Irrigation and Revenue officers regarding the prevalence of 'kalar' or alkali in Sind, and the following is a résumé of their opinions :— Mr. H. C. Mules, Collector of Karáchi:

"In former days grants of kalar land were made on very easy terms with a view to their reclamation. They were thoroughly washed, *i. e.*, flooded, and the water held on them by 'bund' for a year or two, then rice was grown. The finest rice lands in Sind, producing a quality of rice known far beyond the boundaries of the Province are known as the 'Mail' in the Lárkána District, near Gogharo. These lands were formerly rank bad kalar. Some very bad kalar lands were granted many years ago on a reclamation lease to the late Seth Ramchand of Khorewah, a very enterprising zemindar who in course of time obtained excellent results. There are concrete instances but the same kind of thing is going on all over the country on varying scale.

"A very striking instance of the movement of sub-soil salt induced by the action of irrigation channels or floods is to be seen at Jacobabad. For one who remembers Jacobabad in the early seventies the change is very remarkable. Then the land in cantonments was sweet, the wells were sweet and the water good, the gardens were remarkable for their luxuriant growth and the vegetables raised therein were every bit as good as the best English vegetables. Now the whole place is salt, the wells are many of them useless and the gardens have died away. But you have only to ride beyond the limits from which floods were excluded to find the lands which were flooded, washed and subsequently irrigated bearing splendid crops. And I may say that hundreds of villages have been similarly affected. It is quite common to find the village site rank kalar and the surrounding fields sweet and productive.

"It will, I think, be found that the way to eradicate salts is to wash it out. Wherever there is good head of water and a reliable supply this is possible. But, of course, it is essential to drain off the water used for the washing; take the instance of 'Puncho' water. It is by no means uncommon to hear officers speak of this system of passing off water after it has stood on the rice for a little while as waste of water. It is not so: the cultivators know perfectly well that the water gets sour and must be passed away before it becomes so and injures the crop. Therefore depressions and low grounds are used for the reception of 'Puncho pani' and the crops receive constant fresh supplies. In the same way it is necessary to pass away and renew water used for washing the land."

Mr. G. E. Chatfield, Colonisation Officer, Jamrao Canal:

"Salt or kalar land is to be found in the Jamrao tract, as in the rest of Sind, in large quantities. The salts are of different kinds and have different effects, some being almost harmless and others noxious to cultivation, some easily soluble in water and others not so. Native cultivators call them by different names ('White', 'Red?, 'Black' kalar) and have hazy knowledge of their effects."

In the Jamrao tracts there are large stretches of kalar lands, which are regarded as uncultivable Much of this land would be cultivated were it "flow" but owing to the tendency of kalar to seek the highest lands such large kalar patches are usually lift. Besides these, there are small sporadic patches of kalar scattered over the whole tract, so closely that scarcely any village, however excellent the soil, is without them. From a comparison of the land which is under perennial irrigation with the surrounding land, I should say that these patches had always been there and that irrigation is not responsible for the appearance, though it increases their size. It is difficult to observe sporadic patches of this kind, but from the general complaints of cultivators as well as from what I have actually observed in certain parts of the tract (e.g. near Mirpurkhás and in dehs 87, 88, 89), it seems that in many places kalar is spreading with irrigation (percolation, on the other hand, brings up kalar where none was previously found and the land on either side of the canal, Minor and water course is almost invariably rank kalar for a considerable distance). Against this I must add that in many villages the kalar is certainly being washed down out of the soil by means of irrigation.

In comparing Jamrao lands with those on inundation canals it must be remembered that the latter are generally lift lands or rice lands: for when the Sindhi can get flow he will generally grow rice. In rice lands kalar is a matter of small importance, and in lift villages the water is generally sufficient for a mere fraction of the whole area, which fact enables the zemindar to pick and choose his land. Villages on the Central-Hyderabad canals contain many waste numbers which are not taken up on account of kalar but which would be taken up were these villages brought upon the Jamrao canal.

About the causes of the appearance of kalar I have little to add. In lands which have never been under irrigation it is nearly always present though in varying quantities, and with irrigation it sometimes increases and sometimes decreases, according to the nature of the sub-soil. The only remedy known in Sind is to wash down salt into the sub-soil with heavy waterings. For this purpose it is usual to start with some crop which can stand a certain amount of kalar. The crop which is preferred is rice; some of the inferior millets (e. g., sao), wheat and *jambho* are also grown in such cases. I cannot record any very brilliant successes in the reclamation of land on the Jamrao, though some lands have undoubtedly been improved by cultivation in Digri and Jamesabad.

Rice is undoubtedly well suited to *kalar* lands and the heavy flooding which it requires improves the land immensely. This crop is forbidden on the Jamráo and could not be permitted without a great loss of revenue. Neither is it a remedy suited otherwise to the tract; for while heavy flooding sweetens the land flooded it causes the salt to rise in the adjacent lands. Moreover, the worse stretches of *kalar* are usually too high for flow irrigation.

In rice districts, such as the south of Hyderabad, of which I had formerly charge, it is only the worse kind of *kalar* which is regarded as uncultivable. But where much salt was present in the soil it was found necessary to change the water very frequently. This was effected by letting out the water from the cultivation into the ditches and depressions which surrounded the fields; unless this was done frequently the crop was believed to suffer.

Much land on the Jamrao is undoubtedly deteriorating under irrigation and becoming *kalar*. Much land has not been taken up because it contains *kalar*. Much that has been taken up is not paying for the same reason. The recent rise of cultivation on the Jamrao is chiefly due to the giving out of fresh lands in 1905, and in any case would scarcely affect the question."

Mr. G. McC. Harrison, Superintending Engineer, Indus Left Bank Division :---

"There appear to be three kinds of alkali known in Sind :----

I.- Rapri kalar, or chloride of sodium, from which salt was manufactured before for use in Sind. Oil-seeds will grow on lands infiltrated by this kind of *alkali*.

II.-Bhanothi kalar.—This is generally found where old village sites once stood, or where leaves and other *déhris* decay. This is probably sulphate of sodium from which Glauber's salt was once manufactured near Sehwán old fort. Such *kalar* is collected and used as manure for crops. Its area is insignificant.

III.—Dudh kalar, or carbonate of sodium, is seen in arid high level lands. Rice can be grown on these lands if there is plenty of water."

It would undoubtedly be of the greatest use if an *alkali* map of Sind were prepared. In the tract of the proposed Rohri-Hyderabad canal such a map will be extremely useful; here there are no doubt isolated portions of land which owing to *alkali* are useful for any or only rice cultivation. In such portions minor canals or distributaries could be left out altogether or designed for rice cultivation.

Mr. F. St. J. Gebbie, Executive Engineer, Jamráo Canal :---

"For some years past there have been vague complaints that owing to the evil qualities of the Jamráo water all the land is turning to *kalar*. I have asked many zamindárs to show me land which, before the Jamráo was constructed, had no *kalar* in it and which has now become unculturable, but no one has yet done so.

It is true that there is now much larger area of *kalar* land in the Jamráo tract than there was before the canal was constructed; but that is due to the large area of what was formerly waste and is now being cultivated. A good deal of this waste land was *kalar*, but the *kalar* did not become visible till it was irrigated.

I know of no remedy for *kalar* except careful cultivation and manuring. I have heard a great deal of growing rice to wash out the *kalar* but I have still to see a case in which this has been done and any other crop except rice grown on the land afterwards. The Sindhi in these parts is a great believer in this system; but it seems to me he makes such a strong point of it rather to try and get permission to grow rice than with any idea of really washing the *kalar* out of the land. All Sindhis are anxious to grow rice because it suits their lazy slipshod methods of cultivation.

Provided that the people are satisfied with the supply of water as fixed by Government, *viz.*, one cusec for every 300 gross acres, there is no objection to allowing them to grow rice on the Jamráo; but they will not be satisfied with this. They say that rice wants a constant supply and they cannot be given this under existing conditions. With the outlets and water-courses as they are, the only efficient method of distributing water fairly to everyone in a village is by 'share lists' as is done in the Punjáb. But if any man is to get water constantly a share list cannot be prepared and he must get water at the expense of other cultivators in the village.

Since the Jamráo was constructed about 57 per cent. of the culturable area of village No. 18 has been cultivated annually and practically all by flow; but no *kalar* has appeared because there never was any in the soil. On the other hand, village No. 38, in

which about 20 per cent. area is cultivated all on lift, is beginning to show *kalar* in many places."

In summing up the Commissioner in Sind stated :----

"The reports submitted scarcely give an adequate idea of its extensive prevalence throughout the province, owing to the nonexistence of any statistics on the subject. Even materials for a rough estimate of any degree of reliability are not available. It is hardly possible to say more than that the occurrence of saline area, in every gradation from isolated patches to continuous barren tract many miles in extent, is one of the most familiar features in Sind; and the gravity of the evil is to be measured, not only by the diminution in the cultivated area and the injury to crops occasioned in localities where attempts are being made to control it, but also the permanent exclusion from cultivation of large areas of otherwise valuable lands."

CHAPTER IV.

Cultivation in Sind.

Sind cultivation is almost entirely dependent on irrigation from canals from the river Indus. It is a hot arid country, having the highest temperature in India.

	July.	August.	September.	Octob r.	Novemb=r,	Dccemb .r.	January.	February.	March.	April.	May.	June.	Fotal,
Maximum	ıot	102	111	101	95	92	93	103	97	115	121	118	•••
Minimum	67	74	72	65	44	42	45	44	46	61	70	75	•••

Shade temperature at Mirpurhhás, 1911-1912.

Rainfall.

1911-1912						·06	 .36				 	0.42
Average of 5 years	last 	4 45	3.26	0'43	••••	0.1	 0.53	•••	0.3	0.5	 1'4	9.66

 \sim In Upper Sind the temperature is higher and the rainfall is less.

The country has a natural slope of about 150 feet from north to south. The canals generally were constructed long before the British occupation; they flow when the Indus is in flood, in the hot weather, and are dry during the remainder of the year. They often take off at a right angle from the river and do not take full advantage of the slope of the country. At the head of these canals the water may have to be lifted by Persian wheels and at the tails often there is too much water and rice is cultivated. Except in the extreme south a good natural d ainage is obtainable and the water table is often 20-30 feet deep. The population is small and it is locally believed that except in the case of rice cultivation land requires to be fallow for several years. Under the circumstances the question of *kalar* is not so important as it will be when the country fills up. When water is available there is probably no kalar land in Sind that will not grow coarse red rice, the kalar being removed partly by surface washing and partly by washing the salts down into the sub-soil. As the surface water gets salt it is drained off into neighbouring *dhunds* or depressions. When some of the *kalar* has been removed better quality of rices can be grown. The methods are rough and ready and entail an expenditure of much water and may do some damage to neighbouring lands. Under indigenous methods where there is not a large surplus of water practically nothing can be done with really bad kalar.

On the whole, the *kalar* problem in Sind cannot be said to be a very difficult one except on the existing perennial canal—the Jamráo and on the projected perennial canals which will gradually take the place of the inundation canals. But the country has the great advantage of having at present the sub-soil water table at considerable depth. On the perennial canals the indigenous methods of swamping the *kalar* land would not be possible; water would be carefully distributed and the land properly squared and delineated.

Land is often however labelled *kalar* which really contains only a small percentage of *alkali* salts, and in such land, which generally contains a good percentage of sweet soil quite good crops can be obtained by using a little extra water. None of the lands so far examined in use for agricultural purposes contain very high percentage of *alkali*, but a number of these contain just sufficient *kalar* to have an injurious effect on the yields of the crops.

CHAPTER V.

Reclamation Experiments in Sind.

Reclamation experiments have been carried out at Mirpurkhás, Daulatpur and at Sukkur. These cover the two chief types of soils in Sind—the heavy, retentive, clayish soils near the river Indus and its old branches, and the other lighter and much less retentive. The one (Sukkur) will grow *bosi* (*i. e*, with an irrigation in the hot weather and suitable ploughing thereafter, cold weather crops can be obtained without further irrigation), the others will not. They all come under class I, the sub-soil water level being 18' to 20' deep.

At Mirpurkhás on taking over charge in 1907 it was found that on part of the farm no crops would grow. The history of the plots is as follows :----

	Se N	ries C. 0. 13.	Seri No.	es C. 14.	Seri No	es C. 15.	Seri No	ез С. 16.	
	Sur- face.	2' deep.	Surface.	2' de :p.	- Surface.	2' deep.	Surface.	2' deep.	
Sodium carbonate	;								
" bicarbonate		·0292	[.] 0375	•0375	.0292	'0417	[.] 0541	·0417	
" sulphate	; ·, •••		•••						
" chloride	0238	•4828		•			••••		
Magnesium sulphate			·0277	•-•				•••	
" chloride…	·0214	-1583	[.] 0293	·0556	·0332		•••		
Potassium sulphate				•••					
" chloride		'00276	-0199	'0122	. 0491	·0184		.01231	
Calcium sulphate	·0204	-2741	[.] 2720	0583	. 0350	·029 I	.01100	.01160	
" chloride	.0227	·0371		. 0 467	1212	.0121	·0182	*0182	
Total soluble salt	•1308	[.] 98426	.2864	.5103	.1043	.1043	·08396	·08687	
1906.	Rec 4 tor	: :ived ns lim :,	Rece 4 tons g	ived Sypsum,	Rec 4 tons	ived lime.	Noth	ing.	
1906 Hot weather.	Sindh No gar	i cotton. mination.	Jow Somegr	ári. en fodd r.	Jow: Some gree	ári. 2n fodder.	Jow Som : gree	ári. en fodd er .	
1907 Hot weather.	Jo No ger	wári. mination.	Sindhi No germ	cotton iination.	Sindhi No germ	cotton. ination.	Sindhi cotton. No germination.		

In 1907 the plots were filled with water and kept about 2" deep from 4 to 5 months in each cold weather; afterwards *berseem* was sown :----

1908 Hot weather.	Egyptian cotton. 234 lbs. seed cotton.	Egyptian cotton. 192 lbs. seed cotton.	Egyptian cotton. 207 lbs. seed cotton.	Egyptian cotton. 223 lbs. se d cotton.
1909.	Bájri grain	Bájri grain	Bájri grain	Bájri erain
	229 lbs. ; fodder	333 lbs. ; fodder	178 lbs. ; fodder	215 lbs. ; fodder
	2,817 lbs.	3,400 lbs.	1,110 lbs.	1,845 lbs.
1910.	Sindhi cotton. No water, failed.	Sindhi cotton. 183 lbs. seed cotton, crop short from water.	Egyptian cotton. 364 lbs. seed cotton.	Egyptian cotton. 480 lbs. s æd gi cotton.
1911.	Bájri grain	Bájri grain	Bájri grain	Bájri grain
	372 lbs ; todder	360 lbs ; fodd :r	504 lbs ; fodder	283 lbs ; fodder
	2,093 lbs.	1,592 lbs.	1,558 lbs.	2,446 lbs.

The analyses of plot C are misleading; it was really a very salt plot at beginning.

Quantities are per acre.

At Sukkur the site of the Experiment Farm had to be similarly treated as it was found to be very salt. The plots are still patchy in places but the land after reclamation is very fertile.

At beginning of 1908 work was started at Daulatpur on 400 acres of land which was selected as being typical of the worst areas of *kalar* on the Jamrao. The land was classified as unculturable *kalar*. The Colonization Officer in regard to the land stated :---

"The land selected is available and it certainly is bad *kalar* and suitable for the experiment. Nor can there be any doubt as to the value of the experiment as throwing light on the question of *kalar* generally."

The soil varies from a loam to a sandy loam with patches of sand and it is of a similar character to a considerable depth. On the surface it was a bare yellow stretch with a few salt weeds and mounds of *alkali* dust.

DAULATPUR STATION.

25 Squares of 16 Acres = 400 Acres.



Little Gart Photosince Office, Porna DH.

Salt	Squa 64.	re i	Squ 6	iare 6.		Square ' 68.	Squ 3	iare	s	quare S.
	Sur- face, d	2' own,	Surface.	2' down.	Sur face	c. 2' do	wn. Sur- face.	2' down.	Sur- face,	2' down.
Sodium carbonate			•••							.00526
" bicarbonate .	.0167 .	0250	·0375	·0375	·037	5 .0413	7 0292	· o 334	.0250	·0292
n sulphate		••		·1792			İ	·0450	•••	
" chloride …	"	2838	1.229	. 9134	·263	5 1.094	.0753	·o548	[.] 2284	1'092
Magnesium sulphate.	יו	1027		1180	.006	0 .052	5	·0595		·0757
" chloride.	[.] 0342		[.] 0984		·055	14 091	0385		'0 642	.0213
Potassium sulphate				·01256				.0101		•••
" chloride…	10	01075	• 0 0768	•••	.004	61 .0132	o199 '01		.0169	.0102
Calcium sulphate	.0175	2516	·0525	·1292	176	9 .1156	5 1196	[.] 0884	·oo875	·0340
" chloride	·0356		·1235				.0134		[.] 0483	•••
Total soluble alkali	.1040 .(57385	1.24828	1.32296	543	65 1.4080	59 2959	·2972	-39155	1.29816
Salt.	Sq Surface	uare 7.	wn Surf	Square 24.	own.	Squ 2 Surface.	iare 6. 2' down.	Surfa	Squa 28.	re
Sodium carbonate	•••	.003	43	. .		•••				**8
" bicarbonate .	·0250	-0354	4 '02	086 [°] 02	920	· 0208 6	.02919	02	919	·0291 9
" sulphate	*5939	1179	9	. .		•••				'2004
" chloride	1.032	·3349	9 .29	71 '43	99	3.001	-9218	.78	20	·4871
Magnesium sulphate .	.1132	129;	7	• .		•••	***	•04	14	·0939
" chloride .	•••		-14	97 18	40	-3208	.1283	.04	853	•••
Potassium sulphate	·oo538	.003	59	-		•••	•••			.01430
" chloride	•••		.00	б14 <mark>.</mark> оо	614	·01689	.01323	10.	382	•••
Calcium sulphate	·2312	.020	41 35	28 29	75	· 35 8 7	.0320	'20	40	·2209
" chloride				71 .02	70 	-2289	.1212	····		
Total soluble alkali	2.00398	645	33 '94:	370 1.01	374	4.00712	1.24902	1.11	894	1.04585

Analyses of Daulatpur Soils.

CHAPTER VI.

Work at Daulatpur.

Map No. 1 shows the situation of the land, and the contour lines are marked showing a drop of about 4' from south-west to north-east, that is away from the "Minor" as the canal distributary is called). The canal and drains were made as per plan II and III of the following dimensions :—

					Top width.	Depth.	Bed width.
~		Canals.					
Canal from outlet					7	3′	2′
Main canal .		•••			6′	2' 6"	2'
Secondary canal					4′	2'	1'
		Drain1.					!
Main Drain	•••	•••		•••	4′ 6″	3' 6"	f 1'5″
Discharge Drain	•••	•••		•••	4'	3' 6"	1' 5″
Secondary Drain		•••	-		3' 6"	2' 6"	1'
Tertiary Drain (In	hltr.	ation Drain)	•••		3'	2′	o' 9″

A drainage outlet was obtained into a depression about $\frac{1}{2}$ a mile away. The plots are gross 150 × 50 yards or net $1\frac{1}{2}$ acres. A road goes alongside each secondary canal giving communication with each plot. The above earthwork at Rs. 3 per 1,000 cubic feet cost about Rs. 10 per acre.

In a big scheme the Daulatpur area would form the unit village which could be duplicated as necessary, each village having its own buildings.

The next operation was the levelling, which was done by ploughs working in front of wooden scrapers. It is essential to have the land properly levelled; any difference of level in the plots means hollows where water lodges and alkali accumulates. Levelling is a most expensive operation, and unnecessary levelling means much extra expense. It is not advisable to have adjacent land at very different levels as damage may be done by infiltration. In a

CANALISATION DAULATPUR.

Scale 1-200 Y 45



Main

Roads...... Drains...... Canals

Lithe Gars Photozinco Office, Poono, 1914 .



SECTION FROM NORTH TO SOUTH.

Jory 5°CORDIN £.

SECTION FROM WEST TO EAST.

DAULATPUR. Scole 1 to 14

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Little Gov! Materiacs: Office Anno, 1914.

plot however that does not vary more than a foot it is advisable to put up a central bund and level each part separately, e. g. :---



If A—B represents level of original plot levelled to C—D and in II levelled to C—D and to C¹—D¹, then in levelling I there is double the quantity of earth moved double the distance than in II, *i. e.*, four times the cost.

In practice it was found that letting water into the 50×150 yards plot at one end tended to accumulate alkali at the far end; so all the plots were divided by a central bund, the top portions being watered by a special "add" (water channel) and so fresh water was put on directly to each 75×50 yards portion net $\frac{3}{4}$ of an acre.

Nine pairs of cattle were used, generally 7 scrapers and 2 ploughs. The levelling started in April 1908 and was finished in about twelve months.

As noted above, the allowance on the Jamrao canal is I cusec per 300 acres of land, that is 1/3rd of the land on the canal can be cultivated in a year. Special arrangement was made for Daulatpur land for a supply for all the cultivation. An outlet discharging 3 to 4 cusecs was made in 1908 and a similar outlet in 1909.

CHAPTER VII.

Cropping at Daulatpur.

It was originally intended to fill up as many plots as possible with water about 3" deep and keep them full; but it was found that the coolies would not keep the plots full when nothing was growing in them, so rice and "sao" (pannicum crus-galli) were sown. The object of the Farm was after sweetening the land to get berseem sown and thereafter adopt a two-year rotation:—

			1st year	·	 2nd year.
Hot weather	• • •	 Cotton	•••		 Jowar.
Cold weather		 Berseem	•••	•••	 Berseem.

About 100 plots were so treated. No surface water was allowed to run into the drains except in the case of accidental break of banks. The drains were kept as dry as possible, the water quickly sank through the soil and little water passed through the drainage outlet except after rain. The rice and "sao" were useful as green fodder for the cattle. To get a crop of rice, surface drainage would have been necessary but water could not be spared.

Berseem (Trifolium Alexandrium) was sown but the water supply in the cold weather 1908-09 was poor and it dried off.

In 1909 some plots of cotton were sown but came up poorly and more washing was done.

In 1909 cold weather the water supply was excellent and 200 acres of very good berseem was obtained. Some was made into hay and baled and sold at Rs. 19 per 1,000 lbs.

In 1910, 150 plots of cotton were sown and some jowar. On the whole the cotton was not good though most of it germinated quite well.

In 1910 cold weather 200 acres of berseem were sown and it was intended to get some seed. The canal was shut down for two months for re-modelling and the berseem dried.

In 1911, 180 acres of cotton were sown late but did not do at all well. Water was scarce and boll worm attacked the cotton very badly. This was unfortunate as the germination and young growth were excellent. In 1911 cold weather, 180 acres of berseem were sown. This came up excellently and there was a great demand for it. The contractor who bought the plots sold it green at up to 12 annas per 80 lbs. (maund) in Mirpurkhas. Some of the plots gave 60 maunds a cutting.

In 1912, 150 acres of cotton were sown. This was again late as labour was chiefly put on cutting and threshing berseem for seed. There was a large demand for this seed; and although it was not one of the objects of the Farm to produce seed, the berseem was so good that it was thought advisable to do so. The berseem was cut, but before stacking was spoiled by unexpected rains.

The cotton was not satisfactory.

In rabi, 180 plots of berseem were sown. They did very well and got a very good sale both when cut green and carted and also per plot for tethering cattle on it.

In 1913, 180 acres of cotton were sown. The season was noteworthy for the most unusual deluges : 13" fell in 24 hours and much of the farm was a sheet of water. About 50 acres of cotton were entirely killed off. The remainder, mostly American cotton, yielded well. The average was 5 maunds, and some gave up to seven maunds per acre. Some of it was considered to be the best cotton in the Daulatpur tract. Fifty acres of berseem were stacked for threshing. This was flooded in the rains and quite ruined.

At end of rabi 1913 the Farm was auctioned and it obtained Rs. 26 per acre = Rs. 10,400. This was a poor price, as an offer had been received formerly of Rs. 50 per acre. Much of the land however on the Daulatpur tract was recently given out by Government at nominal rates of Rs. 6 per acre.

To this falls to be added local funds cess and survey expenses of Rs. 650 and Rs. 112 = Rs. 762.

The total paid for the Farm, Rs. 11,162.

The following chart shows the actual treatment of each plot since the Farm started. It can be noticed that part of the Farm land is still practically untouched. These plots are high and water could not be spared for them.

Plot No.		_		-	•		Seri	es I.						\$	Sei	ri e s l	I.
(each 11 acres	s).	19	o 8 .	19	og.	19	10.	19	11.	1712.	191	13.	1908.	1909	,	191	o.
	Ĩ	Kh	. R.	Kh.	R.	Kh	. R.	Kh.	R.	Kh F	Kh.	R.	Kh. R.	Kh. 1	R	<u>К</u> h.	R
I		S.			•				••	***		•			ļ	•••	.
2		S.			-		••		•	•••	••••						
3	••••	S.			•	· · · ·				•		•			l	•	.
4	••••	s.		.				į .									.
5	•		•••	.					• ·	•	 •			í		•••	
6	••••	s.		[···· .			••		•						
7		S.		Ba.	Ba		••] .			.	••					.
8	•••	s.		Ba.		•	••		••	•••	.	••					.
9	•••	S.		B:	в.	[C.		1.		•••	C.	₿.	В.	Ba.		Ċ.	ļ
10	••••	э.		Ba	. В.	С.		.	••		C.	В.	В.	Ba.	в	Ç.	
11	•••		•••	Ba.	В.	C.		•	••	•	C.	Β.	В	Ba,	B.	C.	
12	•••		•••	Ba.	В.	(C.		•	••		с.	B.	В.	¦ Da.	B .	с.	
13	•••		•••	C.	В.	с.		i ·	••	В.	C.	В.	В.	Ba.	B,	с.	
14	•••		•••	C.	P.	C.		•	••	В.	C.	В.	R. B.	Ba.	B.	c.	
15	***		•••	C.	В.	C		•	••	В.	C.	в.	R. B.	M.	B.	C.	
16	•••		•••	C.	В.	с.			••	B.	C.	В.	R. B.] J.	B.	C.	ļ
17	•••		•••) C.	В.	С.	, В.	•	••	B.	C.	В.	R. B.] J.	B.	C.	в.
18	•••		•••	С.	в.	C.	В.	, 	••	В.	C.	В.	.	J .	B.	C.	B.
19	•••		•••	C.	в.	C.	B.	c.		B.⁺) C.		В.	М.	В.	C.	В.
20	***			с.	в.	с.	В.	C.		В.	C.	в	В.	Ba.	В.	с.	В.
21	•••			C.	В.	C .	B.	C.		В.	C .		B.	Ba.	B.	C	B.
22	•••].	В.	Ba.	В.	C.	В.	С.		В.	C.	В.	R. B.	Ba.	B.	C.	в
23	••••] J.	В, Г	М.	В.	C.	В.	C .	B.	W.	C.	B.	R. B.	Ba.	B.	C	в.
24]• ,	В. Г]. 	В.	C.	В. 	C.	R.	W.	C.	B.	R. B.	Ba.	B.	С.	В.
25	••••	J. •	В. В.	M.	в.	C.	В.	C.	В.	W.	C.	Β.	R	Ba.	B.	C.	В.
20	•••	J.	ມີ. ກ	J.	В.		В. –	С.	В. -	W.	C.	B.	R. B.	Ba.	B.	С.	В.
~/ 08	•••]. 1	ש. פ	M. T	В. Р		В.	C.	В. -	W	C.	B.	(R. B.	Ba.	в.	C.	В.
20 	••••	J.	в.	J.	в.	C.	В.	C.	В.	W.	C.	В.	R. B.	Ba.	B .	C.	в.
Kharif (No. Plots).	of	R. G.	9 7	9 C. 9 7 G. 13		C.	20	C.	10	•	C.	20	R. 11	G. :	20	с.	20
Rabi Bersee (No. of Plot	em ts).		7		20		12		6	10 W. 6	·	18	20		19		 12
	S. C.	= Sz = C	wan o otton,	or Sad	<u>э</u> .		R B	. = R - B	ice. ersee	m.		j. Ba	i = Jowar. .= Bajr.	1			

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					Se	eries	; III.	•				Plot No.
1911.	1912.	1913.	1908.	1909.	1910) .	191		19	12.	1913.	(each 11 acres)
Kh. R.	Kh. R.	Kh. R.	Kh. R.	Kh. R.	Kh, I	R.	Kh,	R.	Kh	R.	Kh. R.	
			R. B.	С. В.	J. 1	в.	С.	B.	c.	B.	B,	I
		•••	в.	С. В.	JI	в.	C.	В.	C.	В,	B.	2
•••			R. B.	С. В.	J. 1	в.	C.	B.	C.	B.	B.	3
•••	• •••		R. B.	С. В.	J. I	в.	C.	B.	C.	B.	B.	4
			B.	С. В.	J. 1	B.	C.	B.	C.	B,	В.	5
			Ř. B.	С. В.	J. 1	в.	C.	В.	c.	ъB.	B.	6
			к. В.	C. B.	J. 1	B	C.	B.	C.	B.	B.	7
			R. B.	С. В.	J. 1	B .	c.	В.	c.	B.	B.	8
		С, В.	R. B.	С. В.	J. 1	B .	C.	B.	C.	B.	В.	i 19
		С. В.	R. B	С. В.	J.	В.	C.	B.	C.	B .	B.	10
•••		С. В.	R. B.	С. В.	J.	B .	C.	B.	C.	В.	B.	11
		С. В.	В.	С. В.	J.	В.	C,	B.	C.	B.	B.	12
!	В.	C . 1.		Ba, B.		в	C.	B.]	в	В	. 13
	в.	С. В.		Ba. B.	·	В.	C.	B.	C'	B.	B.	14
	B.	С. В.		Ba. B.	1	в	C.	B .	C.	B .	B.	15
•••	B.	С. В.		Ba. B.		В.	C.	B.	C.	B.	B.	16
	B.	С. В.		Ba. B.	1	в	C.	B.	c.	B.	B.	17
	В.	С. В.	В.	с. в	J.	B	C.	B.	C.	B.	В	181
C.	В.	С. В.	B.	С. В	J.	B .	C.	B.	с.	В.	B.	19
	В.	С. В.	В.	С. В.	J.	В.	C.	В.	c.	В.	В.	20
C. B.	В.	С. В.	В.	с.		ь	C.	В.	C.	В	B.	21
С. В.	В.	С. В.	R. B.	c.		в	C.	В.	C.	В.	B.	22
С. В.	В.	С. В.	R. B.	c.	:	В.	C.	B.	C.	B.	B.	23
С. В.	B.	С. В.	R. B.	C.		B .	c.	B.	C.	B	В.	24
С. В.	B.	С. В.	R. B.	C.	:	В.	С.	B.	C.	B.	В.	25
С. В.	B.	G. B.	R. B.	c.		В.	C.	B.	C.	B.	B,	26
С. В.	B.	С. В.	R. B.	c.	1	B.	C.	В.	с.	Ь.	B.	27
С. В.	<u>.</u> В.	С. В.	R. B.	С.]]	B.	C.	В,	C.	B.	B,	28
C. 10		C. 20	R. 16	C. 23 G. 5	G. 1	15	C.	28	 	28		Kharif (No. of Plots).
8	16	20	23	. 20	2	28	-	 28		2 8	28	Rabi Berseem (No. of Plots).
		M. = M G. = Ki	aize. arif Cerea	L E	$\lambda_{h.} = K$ $\lambda_{h.} = Rat$	l hari bi.	f.	{		W G	. = Wheat. = Gram	

Series V.							s IV	Serie		_				ot No.	PI
1909. 1910.	1909.	1908.	1913.	2.	191	11.	19	10.	19	<u> </u>	190	08.	19	acres).	(each
(h. R. Kh. R.)	Kh. R.	Kh. R.	Kh. R.	R.	Kh.	R.	Kh.	R.	Kh	R.	Kh.	. R.	Kh.		
B.			В.	В,	C.	B,	c.	B.	J.	B.	c.	B.	R.		1
B.			B.	в.	C.	B.	C.	В.	J.	B .	С.	B.	R.		2
S. B. C. B.	S. B.		В.	в.	C.	B .	C.	B.	J.	B.	c .	В.	R.	•••	3
S. B. C. B.	S. B.		B.	B .	C.	в.	C.	В,	J.	В,	C.	B .	R.		4
S. B. C. B.	S. B.		B.	В.	C.	B.	C.	В,	J .	В.	C.	B.	R.	•••	5
5. B. C. B.	S. B.		B.	B .	C.	В.	c.	В.	J	В.	C.	В.	R.		6
C. B. C. B.	С. В.	R. B.	В.	В.	C.	В.	c.	в.	J.	B.	c.	в.	R,		7
С. В. С. В.	C. B.	R. B.	B.	В.	C.	В.	C∙	В.	J.	B.	C.	В.	R	•••	8
С. В. С. В.	С. В.	R. B.	В.	B.	C.	в.	c.	B.	J.	B .	C.	В.	R.	•••	9
С, В. С. В.	С, В.	R. B.	В.	в. [C.	B .	C.	В.	J.	B	C.	В.	R.		10
С. В. С. В.	С. В.	R. B.	B.	В.	C.	в.	C.	В.	J.	в.	; C.	В.	R.	•••	[1
C. B. C. B.	C. B.	R. B.	B.	в.	C.	В.	C.	В.	J.	B .	с.	B .	R.	•••	2
С. В. С. В.	C. B.	R. B.	B.	В.	c.	В.	C.	В.		B. -	Ba.	•	••	•••	13
С. В. С. В.	C. B.	R. B.	В.	В.	c.	B.	C.	B .		В.	Ba,	¦	••	•••	4
C. B. C. B.	С. В.	R. B.	B.	В.	С.	в.	c.	В.		в.		.	••		5
С. В. С. В.	С. В.	R. B.	B.	В.	C.	В.	C.	в.		в.	1	•		•••	б
S. B. C. B.	S. B.		B.	B.	C.	В.	C.	В.		в.		•			7
S. B. C. B.	S. B.		B.	В.	C.	В.	c.	В.		B. [•	••	•••	8
S. B. C. B.	S. B.		В.	В.	C.	В.	с.	В.		В.	C.	В.			9
S. B. C. B.	S. B.		B.	В.	C.	В.	c.	в.		в.	C .	В.		•••	0
С. В. С. В.	С. В.	R. B.	B.	B.	C.	В.	C.	в.			С.	В.		•••	11
С. В. С. В.	С. В.	R. B.	B.	B.	C.	В.	C.	В.			С.	В.		•••	2
C. B. C. B.	C. B.	R.	B.	B .	C.	B.	C.	В	ł		c.	B .		•••	23
С. В. С. В.	С. В.	R.	B.	B .	c.	В.	с.	Β.	l		C.	В.		•••	24
C. B. C. B.	С. В.	R.	В.	В.	C.	В.	С.	B .			С.	В.	R.		15
С. В. С. В.	С. В.	R.	B.	В.	C.	В.	C.	В.			С.	B .	R.	•••	:6
С. В. С. В.	С. В.	R.	В.	В.	C.	В.	С.	B.			C.	B	R.	•••	27
C. B. C. B.	С. В.	R.	В.	В.	C.	В	C.	B.	I_		C.	В.	R.		:8
R. 8 C. 18 C. 26	R. 8 C. 18	R. 18	•••	28	C.	28	c.	12	G.	22 2	C. G.	16	R.	(No. of s).	Charif Plot
26 28	26	12	28	28		28		28		20		22		Berseem of Plots).	tabi (No.

Plot No.					VI.	ieries	S											
(each 11 acres	13.	19	12.	19	1911	10.	19	19.	190	o8.	19	1913.	1912.	1911.				
	. R.	Kh	R.	Kh.	Kh. R.	. R.	Kh	R.	Kh.	. R.	Kh	Kh. R.	Kh. R.	Kh. R.				
	В.	c.		J.		В.					•	С. В.		c.				
	в.	c.		J.	•••	B.						С. В.		C.				
1 1	В.	C.		J.	•••	B.	c.	B.	S.	••	•	С. В.		С.				
l	В,	C.		[.] J.	••••	B.	C.	в.	S.		•	С. В.		С.				
l	B.	C.		J.		B.	C.	в.	s.	••	•	С. В.		C.				
		C.		J.	••••	В.	c.	в.	S.		•	С. В.		C.				
	ļ	C.		J.		В.	с.	В.	J.	B,	R.	C. 3 B.		C.				
l		С.		J.		B.	с.	В.	Ba.	В.	R.	С. <u></u> В.	•••	С.				
-		C.		J.			C.	В.	Ba.	B.	R.	С. јВ.	· · · ·	C.				
1		C.		. J.			С.	B.	Ba.	В.	R.	С. 4В.		C.				
I		c.		J.	•••		c.		Ba.	В.	R.	С. ЈВ.	····	С. В.				
I		C.	В.	J.			C.		Ba.	B.	R.	C. ₿.	В.	С. В.				
I	!	C.	В,	' J.			c.		Ba.	B . 1	R.	С.	B.	C. B.				
ł	I	С.	В.	J.	•••		c.		Ba.	B . 1	R.	с.	В.	C. B.				
1	ĺ	C.	B .	J.	•••		C.		Ba.	В.	R.	с.	В.	С. В.				
1	B.	C.	B.	J.	••••		C.	B.	Ba.	В.	R.	C.	В.	C. B.				
1	₿ Β.	C.	B . :	J.			c.	В.	Ba.	В.	R.	c.	В,	C. B.				
I	1	C.	B .	J.	В.		C.	В.	Ba.	B.	R.	С.	В.	С. В.				
14		C.	В.	J.	В.		C.	в.	Ba.	В.	R.	С.	В.	C. B.				
2		C.	В.	J.	В.	į	С.	в.	Ba.	В.	R.	с.	В.	С. В.				
2		C.	В.	J.	В.	,	C.	B.	Ba.	B.	Ŕ.	С. В.	. В.	C. B.				
2		C.	В.	J.	В.		C.	в.	Ba.	В.	R.	c.	В.	C. B.				
2		C.	В.	J.	В.	ļ	C.	В.	Ba.	В.	R.	С. В.	B.	C. B.				
2.		C.	В.	J.	В.	:	C.	В.	Ba.	В.	R,	С. јВ.	В.	C. B.				
2,		C.	В.	J.	В.	L	C.	В.	Ba.	"В.	R.	С. ქВ.	В.	C. B.				
20		c.	В.	J.	В.		C.	В.	Ba.	В.	R.	C. 1 B.	В.	C. B.				
2		С.	В.	J.	В.		C.	В.	Ba.	В.	R.	С. ј В.	В.	С. В.				
2		C.	В.	J.	В.		C.	В.	Ba.	В.	R.	C.	В.	С. В.				
Kharif (No. o Plots).	28	C.	28	G.	•••	26	C.	4 22	R. G.	22	R.	C. 28		C. 28				
Rabi Bers-en (No. of Plots)	6		17		11	8		21		22		13	17	18				

Plot No.					Serie	s VI	I.					Series VII		
(each 1½ acres).	1908.	190	og.	19	10.	19)]]].	19	12.	1913.	1908.	1909.	1910	
	Kh. R.	Kh.	R.	Kh.	R.	КЬ	. R.	Kh.	R.	Kh. R.	Kh. R.	Kh. R.	Kh. R	
I	•••		.		••									
2			.			.								
3			.											
4				-	••	ļ.	••					•••	•••	
5	•••		•	•	••	ĺ.								
б	•••		•		••						 			
7			•			.				'				
8	•	Į	В.	c.	B.	.		C.	B.	J.		В.	С. В.	
9	•••	ĺ	В.	C.	B.	.	••	C.	В.	J.		В.	С. В.	
10	•••		В.	C.	B.			C.	B.	J.		В.	С. В.	
			В,	c.	B .			C.	B	J.		В.	С. В.	
12			В.	c.	B.			С.	B.	13 J. 13 B.		В.	С. В.	
13	•••		В.	C.	B.			C.	В.	⅓ G. B.		В.	С. В.	
14	• •••		в,	c.	B.	.		C.	B .	Soja B.		B.	С. В.	
15	•••		B .	c.	B.		••	C.	B.	G. B.		В.	С. В.	
16	•••		В.	c.	B.			C.	B.	B,		В.	С. В.	
17	R.	c.	В.	c.	B.			C.	B .	B.		B.	С. В.	
18	R.	с.	в.	c.	B.			С.	В.	B.		В.	С. В.	
19	R.	с.	в.	С.	B.	J.	B .	C.	В.	[.] В,		R. B.	С. В.	
20	R.	с.	B.	C.	в.	J.	B .	C.	B .	B.		Ř. B.	С. В.	
21	R.	C.	в.	c.	В.	J.	B .	C.	Β,	B.		R. B.	С. В.	
22	R.	C .	В.	с.	в.	J.	B .	C.	B .	B.		R. B.	С. В.	
23	R.	C.	в.	c.	B.	J.	В.	С.	В.	B.		R. B.	С. В.	
24	R.	C.	В.	C.	В.	J.	В.	C.	B.	B.		R. B.	С. В.	
25		R.	В.	c.	В.	J.	В.	C.	В.	В.		R. B.	С. В.	
26		R.	В.	c.	B.	J.	B.	C.	B.	B.		R. B.	С. В.	
27		R .	B.	с.		J.	В.	C.	B.	B.		R. B.	C.	
28	R.		B.	C.		J.	В.	C.	B.	B.		R. B.	C.	
Kharif (No. of Plots).	R. 9	C. R.	8 3	c.	21	G.	10	c.	21	G. 8		R. 10	C. 21	
Rabi Berseem (No. of Plots).	••••		21		19		10		21	16		31		

Ba. = Bajri

							5	Serial	1X.						Plot No.
1911.	191	2.	1913.	1908.	190	9.	191	0.	19)11.	919	12.	19	13.	(each 1 ¹ / ₂ acres).
Kh. R	Kh.	R.	Kh. R.	Kh. R.	Kh	. R.	Kh	. R.	Kh	. R.	К.	. R.	Кh.	R.	•
		.		•••	.	••	.						••	•	t
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•/•	i				.	••	.	••	•	••.		••	••	•	ʻ 3
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	C.	B.	J.	•••		B.	C.	В.			с.	B.	C .		8
•••	C.	B.	J.			В.	с.	B.	! .	••	С.	B.	С.		9
•••	С.	В.	J.	•••		В.	C.	B.	į.	••	С.	B.	С.		10
•••	C.	B.	J.			B.	C.	В.	! •	••	С.	B.	С.		11
•••	C.	B.	J.			B,	С.	В.	•	••	С.	B.	С.		12
•••	C.	В.	J.	•••	R.	B.	с.	B.	C.	B.	с.	B.	C.		13
	C.	В.	J. '		R.	B.	с.	B.	C.	В.		В.	C.		14
••••	c.	₿.	rash B.		R.	B.	с.	B.	c.	B.		B.	c.		15
	c.	B.	· B.	•••	R.	B.	c.	B.	c.	В.		B.	с.		16
	c.	в.	В.	•••	R.	В.	с.	B.	C.	B.		B.	С.		17
	C.	B.	B.		R.	B,	c.	B.	C.	B.		B.	с.		. 18
J.	C.	в.	B.		R.	B.	C.	B.	C.	B.		B.	с.		19
J.	c.	B.	В.		R.	B.	С.	B.	C.	B.	1	В.	С.		20
ј . В.	c.	В.	В.	•••	R.	B.	с.	B.	C.	B.		B.	C.		21
ļ. В.	с,	B.	B.		R.	B.	c.	В.	C.	B.		B	С.		22
J. B.	c.	B.	w .	•••	R.	B.	с.	B.	c.	B.		B۰	С.		1 23
J. В.	c.	З.	w.		R.	B.	с.	B.	C.	B.		B.	C.		24
ј. В.	c.	В.	w.		R.	В.	с.	В.	c.	B.		B.	c.		25
J. B.	C.	в.	w .	•••	R.	В.	c.	B.	C.	B.		B.	C.		26
J. В.	c.	В.	w.		R.	B.	с.		C.	B.	Ì	B.	С.		27
j. B.	c.	B.	w.		R.	B.	C.		C.	В.		B.	С.		28
—— G. 10	C.	21	G. 8	***	R.	16	c.	21	C.	14	c.	б	C.	21	Kharif (No. of Plots).
8		21	 8 W. 6		 	21		19		14		21		•	Rabi Berseem (No. of Plots).

Стор	 	1908.	1909.	1910.	1911.	1912.	1913.	Total.
Rice		101	41			•••		142
Cereals	•••	7	62	² 7,	20	28	16	160
Cotton	••••		80	155	118	104	117	574
Total, Kharif	••••	108	183	182	138	132	133	876
Berseem		тоб	189	173	, 131	179	139	917
Wheat	: •••• :	•••		•••	•••	6	6	12
Total, Rabi	••••	106	189	173	131	185	145	929

24 Summary of Cropping.

Total No. of plots cultivated in Kharif876.Do.do.Rabi.g29.Total No. of acres cultivated in Kharif I 314.Do.do.Rabi.I.393.I.393.



View along Secondary Canal, showing road each side with . infiltration drains.



Berseem ready for cutting.

CHAPTER VIII.

Cost and Return of Daulatpur Station.

The following are the amounts actually spent on the station up to March 1914.

Head.	Begin- ning of 1908.	190 8-09 .	1909-10.	1910-11.	1911-12.	1912-13.	1913-14.	Total.
Earthwork	2,960	1,064	500	 	101			4,625
Buildings	283	1 1 3 2	370	131		32	473	2,421
Wages	12	1,455	1,917	3,124	2,467	2,631	3,298	14,916
Cattle Food and Ploughman's wages.	•	2,689	1,053	731	996	916	1,189	7,562
Supervision	·	1,052	883	905	915	840	575	5,170
Seed Bill		1,492	1,708	334	208	•••	44	3,786
Cattle	••••	799	430			So	92	1,401
Total	3,255	9,683	6,861	5,225	4,687	4,499	5,671	39,881
Other heads are :—								
Contingencies	311	337	65	1	94			808
Implements		495	8		• •••			503
Engine and Pump	312	229						541
Buildings	•	651				••••		651
Total 🛼	623	1,712	73	· ·	94	•••		2,503
Grand Total	·3,878	11,395	6,934	5,226	4,781	4,499	5,671	42,384

The items under 'Other heads' are not properly chargeable to the reclamation experiment. They include purchase of Hay Press, Pump and iron pipes which were afterwards used on other farms; also expense on old earthwork, etc., before the farm area was taken over. The actual amount spent on the Daulatpur Farm is thus Rs. 39,881.

25

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Year.		On account of			Rs.	Total Rs.
1909-10		Sa e of 116 Mds. Sinchi seed-cotton Miscellaneous	····		1,079 31	1.110
1910-11		Sale of 191 Mds. Sindhi seed-cotton ,, of berseem green , of berseem hay Miscellaneous	•••	···· ····	1,874 516 556 129	-,
1911-12	•••	Sale of 31 Mds. Sindhi seed-cotton " Ot berseem fodder … Miscellaneous …	 	 	265 500 81	3, 07 5 846
1912-13		(Note—Price of this year's produc paid into treasury in the following f Sale of 193 Mds. of Sindhi seed-cott	e was chi financial ye con	iefly ear.) 	1,938	040
		, of 14 Mds. American' phutis' , of 14 Mds. stained lint , of 14 Mds. American cotton-see , of berseem green fodder Miscellaneous	ed 	••• ••• ••	142 14 8 1,445 156	
1913-14		Sale of 95 Mds. American seed-cotto "of-42 Mds. cotton-seed "of 62 Mds. wheat "of berseem fodder	n last year do. do. do.	r's .	877 212 232 533	3,703
		Sale of 52 Mds. Sindhi seed-cotto , of 150 Mds. Tirumph do. , of 139 Mds. Texas Big Boll , of 17 Mds. last picking , of 93 Mds. American cotton-se , of berseem fodder Miscellaneous	and eed 	<u>}</u>	391 2,623 114 196 1,520 46	1,854
		9 bales of Allen's Long Stapled $= 4$,044 lbs. a	 t 7 anna	us per lh	4,890 1,770
		in transit. Miscellaneous recoveries to be made			por 10.	4,770 200
				Grand	Total	17,448

Revenue from Daulatpur Station paid into the treasury :---

The Balance Sheet stands.

.

Cost.	Return.
Expenses 39,881.	Rs. Sale of land 11,162 Do. bullocks 2,000 Revenue 17,448
	30,610
Leaving a debit balance of o which has to be added ar	9,271

To which has to be added amount to be debited for Government assessment and irrigation.

CHAPTER IX.

Irrigation aspects of Daulatpur Experiments.

The site chosen for the Daulatpur experiment was perhaps unfortunate. Salt land near the river Indus for which irrigation water could have been pumped from the river would have been better. Also the selling price of the land would have been greater. As it happens the land is situated in a tract which has been given out on nominal terms by Government. It is obvious that for profitable land reclamation the district market price for good land should be such as to make the work profitable.

Again, the Jamrao Canal commands roughly 7 lacs of acres of land and is designed to supply irrigation water to a third of this area annually. It was designed to meet the needs of local agricultural practice which consists of growing cotton and jowari or bajri in kharif and wheat in rabi and leaving the land fallow for several years between each crop. This is all very well so long as land is cheap and plentiful and population and labour scarce. But even now conditions are changing. If the Sukkur barrage and triple canal scheme or any new perennial canal were constructed a higher percentage of cultivation would be necessary to make the scheme pay. To get this higher percentage it would not be possible to simply cut out the fallows. With more intensive cultivation rotation crops must be included and for this purpose berseem here as in Egypt has proved itself to be not only the best but the only suitable leguminous rotation crop.

The modus operandi was to get rid of the salt by washing down into the sub-soil and then grading the soil up by growing repeated crops of berseem. So the farm practice of keeping the soil as much as possible under a crop was quite contrary to the local practice of constant fallows.

According to canal rules water would only have been supplied for $\frac{1}{3}$ of the farm land per year or a opening designed to supply 1 cusec for each 300 acres of gross area. So a special water supply was given to the farm. This supply was estimated by the Executive Engineer, Jamrao Canal, at 3 cusecs in 1908 and 5.5 cusecs thereafter when a second opening or outlet was constructed and when the water was flowing in the Minor.

As the discharge of the Mirpur Minor is about 40 cusecs the amount supplied to the farm meant a serious diminution of the total available amount of water for the rest of the tract, so the farm was somewhat unpopular with zemindars and others. On the other hand, the 5.5 cusecs was not sufficient to reclaim the land quickly or to enable the 35 high plots near the main canal to be taken in hand. To do this it would have been necessary to cultivate rice (or wash with an equivalent amount of water) in the whole area for one season and in about $\frac{1}{2}$ the area for a second season. This rice growing could not have been done with less than a duty of 25 which would have meant a supply of 16 cusecs for the first season and about 10 cusecs for the second.

There was a general idea that the farm was receiving a much larger supply of water than the usual zemindary land. This, however, was only the case looking to the gross area supply per acre. Per acre of cultivated crop the amount of water used by the farm was less than that used by the zemindars in the tract. In the following table it is shown that with the water used by the farm to cultivate 2,506 acres, 2,487 acres were cultivated by local zemindars. The difference would be much more in favour of the farm if the water used for rice in the first two years were excluded.

28

Season.	Average water supplied to farm with full supply level in Minor.	Cultivation on Minor (excluding cultivation on farm).	Average water supply with full suppty level in Minor (exclud- ing supply for farm).	Duty = 3 ÷ 4.	Area culti- vated on farm.	Area for which water supplied (2 × 5).	Remarks.
	2	3	4	5	6	7	. 8
	Cusecs.	Acres.	Cusecs.		A. g.	A. g.	
1908 Kharif	3.0	4,275	41	104.3	165 O	313 0	
1908-09 Rabi	4.0	310	38	8∙2	151 20	33 0	
1903 Kharif	6·3	2,554	36	70 [.] 9	. 279 0	447 O	
1909-10 Rabi	<u>6</u> .o	780	37	21.1	280 20	127 0	
1910 Kharif	6 [.] 0	3,244	39	83.2	316 20	499 o	
1910-11 Rabi	. <i>.</i> 5 [.] 8	349	44	7.9	259 20	46 O '	
1911 Kharif	4.7	2,066	41	50.4	210 0	237 O	
1911-12 Rabi	6.8	709	36	19.7	168 o	134 O	
1912 Kharif	4.5	2,125	40	53.1	196 20	239 O i	
1912-13 Rabi	7.7	619	38	16.3	277 20	126 0	
1913 Kharif	5.5	2,133	41	52.0	199 20	286 O	
						<u> </u>	
				Total	2,506 20	2,487 O	

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(Signed) C. W. E. ARBUTHNOT, Acting Executive Engineer, Jamrao Canal District.

There comes the question what has to be charged against the farm for the amount of water supplied. The combined revenue assessment and irrigation rate for the Daulatpur tract is as under :--

Cotton	 • • •	Rs. 4 per acre.
Kharif Cereal	 	Rs. 3 per acre.
Wheat	 	Rs. $3/12$ per acre.
Berseem	 	Re. 1 per acre.

Rice is not allowed except in special circumstances, when permission is given, however, the rate is Rs. 4 per acre.

So	Rs.
Rice-213 acres at Rs. 4 per acre = Kharif Cereal-210 acres at Rs. 3 per acre =	852 720
Cotton—861 acres at Rs. 4 per acre = Berseem—1,375 acres at Re. 1 per acre = Wheat—18 acres at Rs. 2/12 per acre =	3,444 1,375 67/8
Total =	6,458/8

The Executive Engineer, Jamrao Canal, in his letter No. 2459, dated the 30th April 1914, is of the opinion that the water should be charged at the following scale :--

1			Duti	es.	Assess	Assessment.			
Year.	Discharge.		Kharif.	Rabi.	Kharif.	Rabi.			
1908	3 cusecs		80	38	240	114			
1909-11	5.5 "	• • •	80	38	1,320	627			
	Total		••••	•••	1,560	741			
	1,560 acres a 714 acres al	t Rs. 3 : Rs. 2	3-8-0 per acr -9-6 per acr	e e	Rs 5,46 1,92	50 26			

This would represent the value of the water supplied to the farm if it had been used on good land on some other part of the Jamrao Canal (up to end of rabi season 1911).

The former figure would probably be fair if the water had been used on the Daulatpur tract (outside the farm) as the standard of duties there is lower than for the average Jamrao.

CHAPTER X.

Conclusions.

As it stands the Daulatpur farm has not paid. If it had sold at Rs. 50 per acre it would have cleared expenditure. There was a profit in the last year of working of Rs. 2,110 as follows :----

Expenditure.	Assessment.			Return.
Rs. 5,671	Jowári—24 acres at Rs. 3 Cotton—174 acres at Rs. 4 Berseem—139 acres at Re. 1 Wheat—6 acres at Rs. 3-12-0 Total	···· ··· ···	Rs. 72 700 139 22 933	Rs. 8,714
	Profit	•••	8,714 6,604 2,110	

There is no reason to doubt that the farm would have continued to show a profit each year.

It was proposed at one time to use the farm for the production of American cotton seed and berseem seed for distribution to Zamindárs, but an area of 200 acres near Mirpurkhas was acquired by Government for this purpose, and as it was not convenient to work two such areas the Daulatpur farm had to be sold.

Though there is no practical possibility of the extension of this system on the Jamrao, as there is sufficient good land to utilise all the water available, and further reclamation experiments would mean using water which would otherwise be used for growing crops on good land, still the importance lies in view of the coming new perennial canals. In these the present long fallows will be impossible, some rotation will have to be practised. One other demonstration however has been arranged for 1,500 acres of land, to show on a commercial basis the feasibility of keeping the land under constant cropping with the abovementioned rotation. The grantee has Egyptian experience.

On the proposed new perennial canals the cultivation will have to be more intensive and the water-supply will probably be at least 1 cusec for 200 acres gross, so sufficient margin will be available for dealing with kalar lands. Applications to grow rice for reclamation purposes could be granted provided the land is properly levelled and laid off to begin with, and the applicant willing to keep to a certain rotation. The levelling of the land will be a test of a *bona-fide* applicant. On bad kalar ground small drains to divide the plots are essential even with a low sub-soil water level. If plots are separated simply by bunds, a breach in one of them might mean the work having to be done over again. The earth from the small drains is also useful for making bunds.

The low sub-soil water and consequent good drainage found in Sind is a great asset and simplifies reclamation work exceedingly. If the sub-soil water were near the surface instead of being about 20 feet deep the kalar problem would be much more serious.

Outside a perennial canal kalar lands can easily be dealt with by Zamindárs when water is available. Such land will probably be given out on easy terms to Zamindárs, and where water for rice is available by a mixture of surface drainage and washing the salt into the sub-soil the lands will be improved. For high lying bad kalar probably no one would take it up and such land is likely to be vacant till the pressure of population increases.

For perennial canals more stringent rules would have to be applied. On lightish land which is accurately levelled and arranged so that sweet water can be turned into each $\frac{3}{4}$ -acre plot separately, then one rice crop would enable most of the land to grow berseem and two crops of rice would about complete the reclamation. For heavier land such as that in Sukkur Farm probably three crops of rice would be required followed by berseem. The rice is simply a means to an end, if a crop is required surface drainage would be required to run off the surface water when it contains too strong a solution of alkali salts.

One point brought out in the reclamation experiments is the importance of berseem. Seed from North Egypt was first tried in Sind about 7 years ago and it has ever since proved itself to be a splendid rotation crop for the country. Berseem is the backbone

PLATE NO. 3



Cattle on Berseem Plots.

of Egyptian agriculture. Some $1\frac{1}{2}$ million acres are cultivated there per season. It enables a most intensive system of cropping to be carried on without exhausting the land. It seems to grow as well in Sind as it does in Egypt. Berseem has proved itself to be splendid rotation fodder crop for Sind. It is suitable for saline land as it stands a considerable amount of water. It is a cold weather crop and can be sown in October. The seed requires to be broadcasted in water, if standing cotton is irrigated berseem seed can be broadcasted in the water and when the cotton stalks are ready to be cut out, the berseem will be ready for the first cutting. During the cold weather if water is available it will give 3 to 4 cuttings and can be ploughed in March for cotton. It will seed in April-May, but the seed-yield as in the case of lucerne and clovers is low. When required for seed it should be allowed to remain uncut from February. As much as possible of the berseem at Daulatpur was sold to be eaten by cattle tethered in it. One acre of good berseem will feed 100 cattle for a day if they are properly tethered in it. Imported Egyptian seed is expensive—about Rs. 7 per acre.

It is to be remembered that rice, sao, berseem, etc., owe their value as reclamation crops not because they can withstand a large amount of kalar but because they can withstand a large amount of water. In the wet soil the soil water will only contain a weak solution of injurious alkali; if the same soil were dry the solution would be stronger and might injure a crop like cotton.

It has been noted that village sites and buildings sites especially those surrounded by rice fields are very salt. The alkali salts rise even in burnt brick buildings and gradually eat them away. If the sites of buildings in kalar areas were thoroughly washed for 6 months or one year before buildings were constructed, they would not be damaged by kalar.

Glossary.

Kalar.-Sindhi word used for alkali land.

Bunds.-Banks of earth round fields for irrigation purposes.

Flow land.—Land which can be irrigated by water run on by gravitation.

Lift land.—Land which has to be irrigated by raising water by Persian wheel or other lift.

Perennial Canal.—Canal which has water in it all the year round.

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Inundation Canal.—Canal which has water in it only during the Indus floods—generally June to October.

Cusec.--A cubic foot of water per second.

Minor.-The distributary branch of the canal.

Add .--- Small field water channel.

Sao.—Pannicum crus-galli.

Jambho.—Rape (eruca sativus).

Jowári.-Sorghum (andropogon sorghum var vulgare).

Bajri.-Millet (pennisetum typhoideum).

Berseem.-Egyptian white clover (trifolium Alexandrium).

Maund.—80 lbs.

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Subject.

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31	1908	Establishment and Management of the Dairy Farm, by G. K. Kelkar, Assistant Professor of Agriculture	o	3	0
32	1908	Locusts in India, by H. M. Lefroy, Imperial Entomologist, Pusa	O	8	0
33 ⁻	19:9	Cultivation of Broach Cotton in Dhárwár, by M. L. Kulkarni, Divisional inspector of Agriculture, S. D	o	4	0
34	190 9	Night-soil—A Valuable Manure, by G. K. Kelkar, Assistant Professor of Agriculture, Agricultural College, Poona	o	4	0
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