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Water Allowance for Reclamation in High Watertable Areas

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INTRODUCTION

The soils in canal colonies of the Punjab are suffering badly from salinity. In many parts the menace has increased to such an extent that arable and fertile soils are being rendered barren to the serious deteriment of the prosperity of this Province. The method evolved by the Land Reclamation Department to combat this calamity, the one which has been in vogue for the last two decades, consists of washing down the salts by excessive leaching and rice cultivation during the summar months, when enough discharge is available in the rivers. Water supply for reclamation is provided at a low water duty of 45 acres per cusec. This low reclamation water duty is based on practical experience on areas having high salt content and watertable beyond 10'. Evidently the successful washing down of salts depends upon the continuous movement of water from soil surface towards the watertable. On theoretical considerations of capillary forces and movement of moisture, and in the absence of any definite data a 10' depth below the soil surface has been assumed to be the safe depth to which the salts should be depressed for successful reclamation. (1)

The problem of the rise of watertable in the canal colonies of the Punjab has also been receiving serious attention of the Government during the last three decades. The ultimate result of the rise of watertable is waterlogging which has already occurred in certain parts and is readily foreseen in others. Waterlogging creates anarobic conditions which are highly unfavourable to plant growth. The rise of watertable also promotes the upward movement of salts although it is not considered to be the only cause. (2)

While proposing measures to check the rise of the subsoil watertable, the additional water supply provided for reclamation was considered to be a contributory cause in accretion to subsoil water reservior and in the year 1945 certain drastic decisions were taken by the Government in this connection. Instead of studying the problem from the point of view of movement of water, moisture holding capacity of the soil and the ultimate removal of salts to safe depths, it was decided that :—

(i) no reclamation supply should be sanctioned for areas where watertable was within 6′ unless field drainage is provided with which the area would pass to category (ii) below ;

(ii) in areas with watertable between 6′ and 10′ from the natural surface reclamation supply should be reduced to 50 per cent of that being already utilized ; and

(iii) reclamation supply may be provided for areas with watertable below 10′ as heretofore.

This change of policy had serious effect on the progress of reclamation in the areas irrigated by the Lower Chanab Canal. Due to general rise of watertable 37 per cent of the area of Rachna Doab has watertable within 10′. Reclamation operations when restricted to areas with watertable beyond 10′, would result in allowing the areas with watertable within 10′ to become saline at a high rate without any check.

Due to the increasing pressure of population on land, the question of reclamation and restoration of saline areas in high watertable zones to

(3)

productivity was re-examined in 1951. Under arid climate a soil profile with deep watertable is generally dry. On the other hand if the watertable is nearer, an appreciable portion of the profile from the watertable upwards is wet due to the rise of moisture under capillarity and as the profile is already moist the washing down of salts would be easier and it would be expected that a higher duty of reclamation supply could achieve reclamation. As there was no scientific data available on the subject it was decided to collect the same through actual experiments in the field and determine :—

(a) the effect of reclamation supply on subsoil watertable under field drainage and without field drainage conditions ; and

(b) the minimum amount of water required for successful reclamation under high watertable conditions in the presence, as well as, in the absence of field drainage facilities.

With this object in view field scale studies were conducted in high watertable areas on Mian Ali Branch of the Lower Chenab Canal from 1951 to 1953. The different treatments compared were :—

1951. 1. 45 acres per cusec with field drains.

2. 45 acres per cusec without field drains.

3. 132 acres per cusec without field drains.

TABLE I

Showing rainfall data from June, 1951 to Jan : 1952.

(for 5 Rainfall Stations)

Date		STATIONS					Monthly Average of 5 Stations.
		Pacca Dulla	Head Mulley	Nanuana.	Jurian Rest House	Ajnian-wala.	
1		2	3	4	5	6	7
1951				**Rainfall in inches**			
June	1	...	0.16	0.50	...	...	
,,	15	...	...	0.10	...	...	
Total	...	...	0.16	0.60	...	...	0.15
July	2	...	...	0.12	0.55	0.35	
,,	3	1.00	1.40	1.17	0.75	0.23	
,,	4	0.70	0.40	0.60	0.50	3.00	
,,	13	...	...	...	0.18	0.22	
,,	14	0.62	0.30	0.35	...	...	
,,	22	...	...	...	0.55	1.05	
,,	24	0.12	0.15	0.45	...	...	
,,	25	2.44	...	...	0.20	0.30	
,,	26	...	0.20	0.30	...	...	
,,	27	...	...	0.05	...	..	
,,	28	...	...	1.00	...	...	
,,	29	...	...	0.20	...	...	
Total	...	4.24	2.45	2.44	2.73	5.15	3.40
August	2	...	0.43	0.60	0.75	1.05	
,,	9	...	0.25	1.00	1.10	0.75	
,,	12	...	0.20	...	...	...	
,,	13	...	...	0.60	0.15	..	

1		2	3	4	5	6	7
August	14	...	0.15	0.25	0.25	0.85	
,,	17	...	...	...	...	1.05	
,,	27	...	0.45	0.45	...	0.85	
Total	...	...	1.48	2.85	3.25	4.55	2.43
September	...	...	...	...	...	...	
October	...	...	...	...	...	...	
November	25	...	0.58	0.70	...	...	
,,	26	...	0 22	0.50	...	...	
Total	...	...	0.80	1.20	...	...	0.40
December	30	...	...	0.60	...	...	0.12
January	1952						
,,	2	0.55	0.82	0.50	...	1.3	
,,	3	0.20	0.45	0.40	...	...	
,,	7	...	0.15	0.35	0.40	0.22	
Total	...	0.75	1.42	1.25	0.40	1.52	1.07

(*b*) **Reclamation Operations.**

The approval of the Chief Engineer for starting the experiment was received during the month of June, 1951. In an area of 696.64 acres reclamation was already in progress under the general scheme of reclamation on field drain conditions. A further selection of 3803.65 acres was immediately completed. Out of the newly selected area (3803.65 acres), supply for 2365.65 acres was provided by the end of June while for the remaining 1438.0 acres shoots (additional turn-outs) were fixed upto the 3rd week of July, 1951.

For a total of 4500.29 acres, 50 shoots, were fixed with a discharge of 66.15 cusecs. The details of the area selected, No. of outlets and discharge sanctioned for the various categories are given below :—

Water duty.	Area selected (acres).	No. of shoots.	Reclamation discharge (cusecs).
A. 45 acres per Cs. with drain.	696.64	12	16.30
B. 45 acres per Cs. without drains,	1438.00	21	31.94
C. 132 acres per Cs. without drains.	2365.65	17	17.91
TOtal ...	4500.29	50	66.15

Except 1438 acres of category B and about one fourth of category A, which had not been under any crop for the previous two harvests, the rest of the area was Cultivated 'Thur'. The area mostly existed in contiguous blocks ranging from 23 to 264 acres in extent. Figure 1 shows the location of various blocks.

The progress on one block of each category is described below in detail for the sake of illustration.

(i) R. D. 37620-R, Mian Ali Branch.

An outlet of 0.85 cusec at R. D. 37620-R was provided for an area of 38.66 acres, at the rate of 45 acres per cusec on drainage basis. About two third of the area was Cultivated Thur and the rest was without any crop for the last one year due to the presence of excessive salts. The soil was of medium loam type, with water able at 2′—6″. Supply was made available in the first week of July. Weekly observations for water-table were started in the first week of July, which are shown in figure 3A.

The highest level recorded, during the pericd of reclamation supply, was 1′—4.1″ in the last week of September and first week of October. It was observed that soon after irrigation, watertable rose by two to three inches but sub-sided subsequently. A rise in watertable was noticed in the last week of January, 1952, as a result of 1.42 inches of rain during the month in that area.

The cultivator made an efficient drainage system for the entire block. The outfall of the collector drain into the Marh-Salar drain was made 'pacca' by the Zemindar. Half of the cost was borne by the Government. Reclamation supply was dis-continued on 15th of October, 1951. The average number of irrigations received by each acre during the season was 12.

(ii) R. D. 39060-L. Mian Ali Branch.

An outlet of 1·75 causecs reclamation discharge was sanctioned at R. D. 39060-L for an area of 78·81 acres at the rate of 1 cusec for 45 acres. The area was out of cultivation for the last five years. No drainage system was provided in the block. The soil was of the medium loam type having small Kankar nodules. The area adjoining the block carried a continuous cover of Lani plants (Atriplex confirlifoba) indicating high pH and high salt content. The outlet was fixed in the second week of July. Initial water table reading was 5′—5·1″. Weekly observations are shown in figure 3B.

The highest reading recorded in the third week of September was 1′—9·3″ during the period of reclamation supply. Water level receded in the following weeks with a sudden rise in the third week of November, apparently due to 0.80″ rainfall during the month in the area. The water table than remained stationary upto the end of January, 1952.

(iii) R. D. 74400-R. Mian Ali Branch.

At this outlet 1·03 cusecs reclamation supply was sanctioned at R. D. 74400-R for 136·88 acres at the rate of 132 acres per cusec with-

out field drains. The area was 'Cultivated Thur'. The soil was heavy and contained Kankar below 1'—6".

Supply was given in the last week of June and observations of watertable were started in the third week of July. When the observation pit was made the free water level first appeared at 5', which rose by 18 inches within one hour. Thereafter its rise was slow and gradual and became stationary at 2'—4·5". Weekly fluctuations in water-table are shown in figure 3C.

The sub soil water rose to highest level (7") in the last week of September and afterwards it began to fall. A rise was observed in the third week of November due to 0·8 inch of rainfall received at Mullay Head. There was a regular fall in subsequent weeks upto second week of January. The rainfall during January had its effect and there was a rise in the third week of the month.

(*c*) **Water-table Fluctuations.**

(*i*) *Reclamation water supply at 45 acres per cusec with drains.*

Reclamation supply at the rate of 1 cusec per 45 acres with the condition of field drains was given at 12 outlets. The total area selected was 696·64 acres for a supply of 16·30 cusecs. The area put under leaching was 692 acres and under rice 666 acres. On an average,13 irrigations were given per acre during the reclamation period.

The mean monthly water-table observations are shown in figure 4A. The initial watertable varied from 2'—3·3" to 6'—5·2" on the various outlets. The average of rainfall observaions during the month of July on the five observation stations was 3·4 inches and the average rise in water table was 5·6 inches.

In the month of August, the water-table had risen further by 8 to 24·7 inches. On an average there was a rise of 15·3 inches in sub soil water level over the rise in July. During the month of August, there was 2·43 inches of rain.

There was no rain during the month of September. On an average there was a rise of 9·91 inches in sub soil water level over the observations taken during August. It was however, observed that there was a definite decrease in the rate of rise of sub soil water level in all cases compared with the observations taken on 30th of July.

There was a general lowering of water-table by the 30th of October compared to the 30th September. On an average there has been a fall of 2 inches during the month.

During the month of November and December, there was a successive fall of 3·9 inches and 7·5 inches in the water-table. By the last week of January there was a rise in the water table by 3 inches, due to 1·07 inches of rainfall during the month.

In all cases a rise of sub-soil water level was observed for the first two months, more so during the month of August. In majority of

cases there was a rise during the month of September but the rate of rise was less due to dry season, The watertable showed a further fall during the month of October. It is observed that under the effect of rainfall an addition to the sub soil water reservoir is more pronounced.

The reclamation water supply having been stopped on the 15th of October, the water table receded during the months of November and December with a small rise in the end of January due to rains.

(*ii*) *Reclamation supply at 45 acres per cusec without drains.*

The reclamation supply at the rate of 1 cusec per 45 acres without drains was given on 21 outlets. The total area selected was 1438 acres for a discharge of 31·94 cusecs. On an average 10 irrigations were given to the various blocks. An area of 1351 acres was put under leaching, out of which 1167 acres carried rice. The general condition of the crop was very poor and the appraised yields very low, the reason being that the area selected in this category was 'ex-cultivated Thur.'

The initial water-table varied from 2′—0″ to 6′—0·5″. The mean initial water-table was 4′—6″, figure 4B.

The average rise in water-table upto 30th of July was 7·6 inches. A futher average rise in the watertable was 5·7 inches during August.

Another average rise of 11·5 inches in the sub soil water level was observed during September. There was a rise of water table as in the case of blocks provided with drains, but the increase during the month of September in blocks without drainage was only 1·6 inches more than in the case of blocks provided with drains. The water level was generally 1·4 inches lower during October than in September. In November a further fall of 5·17 inches was recorded. The rate of fall of water table declined during the month of November and water-table became stationary in December. 0·4 inch and 0·12 inch rainfall was received during the two months, respectively.

The fall in water level continued upto the end of December when a rainfall of 1·07 inches was received and in consequence the water table showed a rise of 4·8 inches during the month of January.

(*iii*) *Reclamation supply at the rate of 132 acres per cusec without drains.*

Reclamation supply at the rate of 132 acres per cusec without drains was given on 17 outlets. An area of 2365·65 acres was selected for a discharge of 17·91 cusecs. 1595 acres were put under leaching out of which 1515 acres carried rice. The area irrigated received 13 waterings on an average during the reclamation period.

Out of 17 blocks observation pits were made only in 5 cases. The mean initial water table was 3′-1″, Fig. 4C. An average rise of 1·8″, in water table was observed on the 30th of July and a further rise of 10·5″ by the 30th of August and a still further rise of 6·2″ on the 30th of September. During October there was an average lowering of water-table on the previous observation by 1·9″. A further fall was

observed on 28th November but the general fall was 3·8″ less than that recorded in October. But for the 0·40″ rain received during the month of November the fall in sub soil water level would have been more rapid. In December there was a general rise of 1·1″ in water-table. During January 1·07″ rainfall was received which caused a rise of 2·3″ in water-table.

2. OBSERVATIONS DURING 1952.

(*a*) **Rainfall.**

The rainfall data from the five observation stations is reproduced below :—

TABLE II

Showing rainfall data from February. 1952 to December. 1952 for 5 rainfall stations

Date		STATIONS					Monthly average of 5 Stations.
		Pacca Dulla	Head Mulley	Nanuana.	Jurian R.H	Ajnian-wala.	
1		2	3	4	5	6	7
1952		**Rainfall in inches**					
January,	2	0.55	0.82	1.30	...	0.50	...
,,	3	0.20	0.45	...	...	0.40	...
,,	7	...	0.15	0.22	0.40	0.35	...
Total	...	0.75	1.42	1.52	0.40	1.25	1.07
February,	4	..	..	..	..	0.25	..
,,	13	..	..	..	..	0.10	..
,,	29	..	..	..	..	0.10	..
Total	..	..	..	..	..	0.45	0.09
March,	7	0.60	0.80	0.65	..	0.70	..
,,	15	0.30	..	..	..	0.50	...
,,	16	0.55	1.55	0.45	..	0.60	..
,,	22	0.50	0.28	0.48	..	0.60	..
,,	23	..	..	..	..	0.22	..
Total	..	1.95	2.63	1.58	..	3.07	1.76

1		2	3	4	5	6	7
April,	4	..	..	..	..	..	..
May,	11	0.30	0.37	...	..	0.20	0.17
June,	5	0.50	0.60	0.35	0.25	0.75	..
,,	8	..	..	0.15	0.05	..	..
,,	21	..	..	0.25	..	..	..
,,	22	..	0.15	..	..	..	..
,,	25	0.15	..	0.65	0.25	..	..
,,	26	..	..	...	..	0.25	..
,,	30	..	0.40	...	..	0.40	..
Total	..	0.65	1.15	1.40	0.55	1.40	1.03
July,	9	0.25	0.08	0.30	..	0.10	..
,,	10	0.15	0.11	0.68	...	0.40	..
,,	11	0.10	..	..	..	..	.
,,	12	..	..	1.12	..	...	..
,,	15	..	0.06	...	..	..	..
,,	16	0.35	0.35	0.50	..	1.00	..
,,	18	...	...	0.55	...	...	...
,,	20	0.25	...	...	...	...	...
,,	22	1.22	0.92	...	0.15	0.50	...
,,	27	0.50	...	0.25	...	...	...
Total	..	2.82	1.52	3.40	0.15	2.00	1.98
August,	5	...	...	...	...	0.70	...
,,	6	1.00	1.38	...	...	0.30	...
,,	8	0.25	0.16	0.50	0.45	...	...
,,	10	...	...	0.60	0.25	...	...
,,	14	.45	0.60	...	...	0.70	...
,,	15	0.15	0.12	...	...	...	...
,,	18	...	0.30	...	...	...	...
,,	20	0.90	0.16	0.30	...	...	...
Total	...	2.75	2.72	1.40	0.70	1.70	1.85

1	2	3	4	5	6	7
September	...	...	...	...	...	...
October	...	...	...	...	...	...
November	...	...	...	...	...	...
December, 19	...	...	...	0.20	...	0.04

It will be observed that during the second half of the year 1951 the total rainfall was 6.35 inches and during the corresponding period in 1952 it was 3.87 inches. The absence of rainfall during the last 4 months of 1952 resulted in considerable lowering of sub soil water-table compared to the fall in the winter of 1951.

(*b*) **Reclamation Operations.**

During Kharif 1952, 9888.94 acres were selected for a discharge of 126.49 cusecs. The area which received reclamation supply at 45 acres and 132 acres per cusec without drains during Kharif 1951 was provided supply at 90 acres per cusec without drains. The details of reclamation discharge proposed and area selected are given below :—

	No. of shoots.	Reclamation discharge.	Area selected.
		Cusecs	Acres
45 acres per cusec without drains ...	29	38.03	1696.59
90 acres per cusec without drains ...	96	88.46	7992.35
Total ...	125	126.49	9688.94

The water table and other observations were extended to 1027 acres out of 9688.94 acres. The area selected was mostly in contiguous blocks varying from 21 to 261 acres.

The outlet at R. D. 37620-R Mian Ali Branch was given supply on field drainage basis at the rate of 45 acres per cusec, while the area at outlet R.D. 62100—R Mian Ali Branch received supply at the rate of 90 acres per cusec. The progress on the two blocks is discussed below in detail.

(*i*) *R. D. 37620-R Mian Ali Branch.*

The year 1952, was the second year of reclamation on this outlet. Weekly observations for water table are graphically shown in Fig. 5 A.

The fluctuations in water-table upto January, 1952 have already been discussed. The watertable showed slight rise during February and March. The level started receding in April and by the third week of May the lowest reading of 1′—8·8″ was recorded. There after the rise began both as a result of summer rainfall and reclamation supply. By September 1952 sub soil water was only 8 inches from the natural surface. However, as a result of stoppage of reclamation supply the watertable began to subside and in last week of December level stood at 1′—6″.

Average number of irrigations received were 20 upto 10th October when supply was stopped.

(*ii*) *R. D. 62100-R Mian Ali Branch.*

The area on this outlet was selected at 132 acres per cusec during Kharif 1951. Most of the area was ' uncultivated Thur ' and the soil of medium loam type. Total area selected was 107·88 acres for a reclamation supply of 1·2 cusecs.

The depth of initial water-table in this block was 2′—5·3″ in July, 1951 and in the course of reclamatlon the water-table rose to 11·3 inches in that year. Afterwards it gradually started subsiding. The level was lowest in January 1952 *i. e.*, 1′—6·2″. From January upto March there was a gradual rise of .4 inches as a result of winter rainfall.

The reclamation supply started in the third week of May 1952 and prior to the start of the supply there was a lowering in sub soil water table by 4·7 inches. This was the result of setting in of summer season. The water table rose to as near as 5″ from the natural surface in the 3rd week of August on account of reclamation supply and Monsoon rains but subsided subsequently. The subsoil water level is shown in figure 5B.

Reclamation shoots were closed on 10th October. Total No. of irrigations applied were 20 against 8 in 1951.

(*c*) **Water-Table Fluctuations.**

(*ii*) *Reclamation Supply at 45 acres per cusec with drains.*

Total area to which reclamation supply was given on field drainage condition at the rate of 45 acres per cusec was 1696·59 acres for which 38·03 cusecs discharge was sanctioned on 29 outlets. Area put under leaching and transplanted with rice was 1668 and 1651 acres *i.e.*, 98·3 and 97·4 per cent, respectively. On an average each acre received 20 irrigations during the season

The mean water-table readings in the 13 pits under observation are plotted in figure 6A. There was a steady rise during January and February which can be attributed to rains received in January and the low rate of evaporation during winter months. As a result of 1·76 inches rain in the month of March, 1·1 inches rise in the watertable was noticed.

However, the rise was temporary and in the following dry month the level fell by 6·8 inches.

Even after the fixation of reclamation shoots in the second fortnight of May the water-table remained steady as there was no rain and the accretion to subsoil was counter-balanced by increase in evaporation. A rise of 2·5″ in water-table was observed after 1·03 inches rain in June. During July the average rainfall was 1·98 inches and the water-table rose by 4·9 inches. In August 1·85 inches rain caused a rise of 5 3 inches. September went dry and a rise of 0·5 inch was registered. There was a steep fall in water-table after September and by the end of December the water-table had gone down to 2′—8·7″ from the natural surface and was less by 1′—5·7″ as compared to the September level. The fall was due to the absence of rains during September, October, November and December. The maximum rise during the reclamation season was 1′—1″.

(*ii*) *Reclamation Supply at 90 acres per cusec without drains.*

Total reclamation discharge sanctioned for this category was 88·46 cusecs for 7992·35 acres supplied through 96 reclamation shoots. An area of 7331 acres was put under leaching and 6824 acres was sown with rice. On an average 19 irrigations were received by each acre in the reclamation season.

Water table readings from 18 pits were recorded weekly. Figure 6B shows the level observed in different months from January 1952 to December, 1952. The level during January was 2′—1·6″. It rose by 3·2 inches in the subsequent month as a result of 0·98 inch rainfall During February there was no rain. In the month of March watertable was 2′—3·8″. Average rainfall received during that month was 1·76″. About 4·8 inches fall was observed by the close of May due to the absence of rainfall and rise in the temperature. In the month of June there was an average rise of 1 4 inches as a result of running of reclamation supply and 1·03 inches average rainfall. In September the watertable was highest *i.e.*, 1′—11·7″. The rise was mainly due to 3·83 inches of rain received in the month of July and August. In October there was no rain which caused a fall in water level by 7·3 inches. During November and December the sub soil water level continued to subside because of reclamation supply. The watertable in the end of December was 3′—3·3″ *i.e*, 1′—3·6″ less than the highest level observed during the reclamation season and 6·7″ less than the depth before the start of reclamation supply.

3. OBSERVATIONS DURING 1953.

(*a*) **Rainfall.**

The rainfall recorded at Pacca Dulla, Head Mullay, Jurrian, Ajanianwala and Nanuana Rest House from January 1953 to March 1954 is reproduced belows :—

TABLE III

Showing rainfall data from January, 1953 to March 1954 for 5 rainfall Stations.

Date	STATIONS. Pacca Dulla	Head Mullay	Jurrian	Ajnian-wala	Nanuana R. H	Monthly Average of 5 stations.
1	2	3	4	5	6	7
1953			**Rainfall in inches**			
January, 1	0.32	0.50	...	...	0.50	
15	0.48	0.52	0.64	0.70	0.54	
16	...	0.60	...	...	0.75	
Total : ...	0.80	1.62	0.64	0.70	1.79	1.11
February 11	...	0.12	0.10	0.50	...	
Total : ...	...	0.12	0.10	0.50	...	0.14
March, 3	...	...	...	...	...	...
April, 19	...	...	...	0.10	...	
Total : ...	...	...	...	0.10	...	.02
May, 17	...	...	0.17	...	0.16	
18	...	...	...	...	0.22	
22	0.15	...	...	...	0.10	
Total : ...	0.15	...	0.17	...	0.48	0.16
June, 19	...	1.10	0.2	0.3	...	
23	...	0.85	0.95	1.0	0.65	
24	0.25	0.50	0.67	0.75	1.00	
Total : ...	0.25	2.45	1.82	2.05	1.65	1.64

1		2	3	4	5	6	7
July,	1	...	0.25	...	...	0.10	
	9	...	...	...	...	0.20	
	11	0.53	0.45	0.14	0.25	...	
	12	...	...	2.05	2.00	6.85	
	13	...	...	...	1.00	...	
	22	...	...	0.60	...	0.20	
	23	...	...	...	...	1.10	
	24	1.10	0.82	2.00	.75	0.20	
	25	0.45	...	0.65	...	...	
Total :	...	2.08	1.52	5.44	4.00	8.65	4.33
August,	1	...	...	...	0.25	0.55	
	5	0.55	0.45	0.87	1.00	0.70	
	10	1.75	0.80	0.25	1.15	0,30	
	12	...	...	...	...	0.42	
	13	0.85	...	...	0.35	...	
	15	...	...	...	0.30	...	
	16	0.95	...	...	...	...	
	17	1.20	...	...	...	...	
	19	1.45	1.35	...	...	1.20	
	20	0.75	...	0.62	0.25	...	
	24	...	...	0.62	0.25	0.40	
	28	...	...	...	0.72	...	
	29	...	...	...	...	0.50	
	31	...	...	0.25	...	0.55	
Total :	...	7.50	2.60	2.61	4.27	4.62	4.32

1		2	3	4	5	6	7
September,	1	2.15	1.65	...	...	2.25	
	2	1.20	...	...	...	0.20	
	9	...	...	...	...	0.25	
	10	0.75	...	0.90	0.50	0.30	
	16	2.75	...	1.10	0.75	1.00	
Total	...	6.85	1.65	2.00	1.25	4.00	3.15
October,	10	...	...	...	...	...	
November,	11	...	...	...	...	...	
December,	12	...	...	...	...	...	
1954							
January,	8	0.45	0.35	0.48	0.66	0.35	
	17	...	...	0,15	...	0.08	
	31	0.25	0.35	...	...	...	
Total	...	0.70	0.70	0.63	0.66	0.43	0.62
February,	2	0.35	0.40	0.25	0.26	0.60	
	5	...	...	0.18	0.10	...	
	18	0.10	...	0.22	0.18	...	
	19	1.20	0.90	0.80	0.26	1.00	
	20	...	...	...	...	0.20	
	24	...	0.50	0.63	0.71	0.40	
Total	...	1.65	1.80	2.08	1.51	2.20	1.84
March,	12	...	...	...	...	0.10	
Total	...	...	...	...	...	0.10	0.02

1953-54 has been a year of ample rainfall. Monsoon rains were heavy and well distributed which were responsible for greater rise in watertable than in 1952-53. Winter rainfall in Rabi 1953-54 was also heavier than in the previous years.

(*b*) **Reclamation Operations.**

Total area selected in Kharif 1953 was 8087.16 acres out of which 2269.55 acres were taken up on field drain conditions at 45 acres per cusec, while the remaining 5817.61 acres were given supply at the rate of 60 acres per cusec without drains. The details of discharge proposed and the number of shoots fixed under each category are given below :—

	No. of shoots.	Reclamation discharge.	Area selected.
45 acres per cusec with drains	41	50.44 Cs.	2269.55 acres
60 acres per cusec without drains ...	83	96.91 ,,	5817.61 ,,
Total ...	124	146.35	8087.16

The observations in this year were made in blocks comprising an area of 1603 acres. The area of the blocks ranged between 20 and 228 acres.

The progress on outlet at R. D. 37620-R Mian Ali Branch which had received reclamation supply on drainage basis for 3 years is compared below with that of R. D. 62100-Mian Ali Branch.

(*i*) *R. D. 37620-R Mian Ali Branch.*

For an area of 38·6 acres selected on this outlet 0·86 cusec discharge was sanctioned for the 3rd year in 1953. The whole of the area was transplanted with rice. The readings of watertable from January, 1953 to March, 1954 are graphically shown in Figure 5A. There was a steady fall in watertable from January upto the end of the March. Rainfall received during January and February did not effect the watertable due to the rise in temperature. Deepest watertable at 2′—5″ was observed in the last week of March. Reclamation shoots were fixed in the second fortnight of April which resulted in 2″ rise during the month. In consequence of the running of reclamation supply and heavy Monsoon rains watertable rose to the surface in the 3rd week of August and did not subside for one month. In the 4th week of September, however, there was a fall in subsoil water level, which continued till the end of December, due to stoppage of reclamation supply and absence of rainfall. During January the watertable rose by about 2″ due to rainfall received during the month. More rain in the month of February resulted in further rise in watertable. There was a fall in the month of March due to the absence of rainfall. Weekly water table reading are plotted in figure 5A.

Reclamation shoot was closed on 10th October. Whole of the area was transplanted with vice in Kharif 1953.

(ii) *R. D. 62100-R Mian Ali Branch.*

For 100·74 acres, 1·61 cusecs supply was sanctioned at 60 acres per cusec without field drains. Reclamation supply was started in the last week of April.

In the beginning of January watertable was 2'-6" from the natural surface. It rose by 6" in two months period due to the rainfall received in January and February. Watertable receded in March as the weather became warm and there was no rain. As a result of fixation of shoots, watertable started rising in the month of April. There was a gradual rise upto the end of June but after wards the heavy rains caused the watertable rapidly to rise to the surface.

From the beginning of August till the end of September free water remained standing on the surface, which was due to rich Monsoon and the running of reclamation supply. After the 4th week of September the level started receding and continued to fall till the first week of February when the reading was 11". Some rise was observed in second fortnight of February, 1954 after rains. The level, however, receded by 7 inches in the subsequent month of March. Figure 5B shows the weekly fluctuations in watertable from January, 1953 to March, 1954. After the stoppage of reclamation supply upto the end of March the fall in subsoil water level was 1'—2" in 6 months period as against the corresponding figure of 2'—2" in the block at R. D. 37620-R Mian Ali Branch.

Reclamation shoots was closed on 10th October 1953. Total number of irrigations given was 19. Whole of the area was transplanted with rice in Kharif 1953.

(c) **Watertable Fluctuations.**

(i) *Reclamation supply at 45 acres per cusec with drains.*

An area of 2269 acres was selected on field drains conditions on 41 outlets. The reclamation discharge sanctioned was 50·44 cusecs. On an average 21 irrigations were given in the reclamation season.

The mean watertable in 13 blocks under observation is shown in the figure 6A.

From January to April there was fall of about 5·1 inches. Reclamation shoots were fixed in the 3rd week of April and water level began to rise. During August it was only 5·8 inches below the natural surface which was 2'—9·5" higher than the level recorded in April 1953. The enormous rise was the result of heavy rainfall and the reclamation supply. During June, July and August on an average 1·64, 4·33 and 4·32 inches of rainfall was received, respectively. The intensity of rain in September was comparatively low *i.e.*, 3·15 inches. Watertable, therefore, showed a fall of 0·3 inch during the month After the closure of reclamation shoots watertable began to recede and by the end of December it was 2'—1·9" from the natrual surface. The level remained more or less constant during January but in February as a result of 1·84 inches

rain, rise of 1'2" in the level was noticed which subsided in the following months.

(*ii*) *Reclamation supply at 60 acres per cusec.*

Total reclamation supply given for this category was 96.91 cusecs which was distributed through 83 reclamation shoots. In all 5817.61 acres were selected. Leaching was given to 5817.61 acres. On an average each acre received 22 waterings during the reclamation period.

Watertable observations are shown in Figure 6B. From 3'—6" mean depth in the beginning of January the watertable fell to 4'-2" in April. The reclamation supply which started in the third week of April caused accretion to watertable and in combination with the Monsoon rains brought the subsoil water level to as near as 9.6 inches from natural surface in the month of August. During September there was a fall of 1.1 inches. Watertable continued to recede till the end of February. The mean watertable depth remained practically constant. The effect of rains in February was counter balanced by rise in temperature.

(*b*) **Efficiency of reclamation supply.**

The efficiency of reclamation supply is to be judged from the percentage of area in which rice could be sown and matured as well as from the stand and the out-turn of the rice crop. The comparative progress under different treatments has been illustrated in figures 7, 8 and 9.

YEAR 1951

(i) Reclamation supply at the rate of 45 acres per cusec with drainage.

In this case total area selected was 696.64 acres of which rice was sown in 666 acres. Appraisement survey was carried on 513 acres. 99% of the area selected was put under leaching while rice was transplanted in 95.5% of the area. In 24 acres, the crop failed altogether. In an area of 46 acres it gave less than 4 maunds yield. Thus the crop was over 12 maunds in 61.87% area. (Fig. 7).

In case of the representative site under this treatment, outlet R.D. 37620—R Mian Ali Branch, the whole of the area selected was put under rice. Area appraised was 32 acres. The stand of the crop was good except in a few ' ex-cultivated Thur ' fields. 15 per cent of the total area or 18.7 per cent of the appraised area was granted remission as the crop yield was below 4 maunds. In another 4 acres yield was between 4 and 8 maunds. The remaining 22 acres yielded 8 maunds or above, (Fig. 7 A).

(ii) Reclamation supply at the rate of 45 acres per cusec without drains.

Out of the total of 1438 acres selected 19% area could not be cropped. Appraisement was done in 956 acres out of which 31.7% failed, 20.7% yielded below 4 maunds and 17.8% yielded 4 to 8 maunds per acre.

Only 20% area gave yield above 12 maunds per acre. The area selected in this category was ' ex-cultivated Thur.' (Fig. 7).

At the representative site of this treatment, outlet R. D. 39060-L Mian Ali Branch, Reclamation discharge of 1.75 cusecs was provided for an area of 78.81 acres and rice was put in 64 acres. The crop was below 4 maunds, in 55.39% of the area appraised, (Fig. 7A). The water supply was continued upto 15th of October and 10 irrigations were given on the average to each field.

(iii) Reclamation supply at the rate of 132 acres per cusec without drains.

In this case rice was sown in 64 per cent. of the area selected. Appraisement survey was conducted in 1111 acres. In 30.2 per cent. appraised area the crop was less than 4 maunds. 7.4 per cent. appraised area gave 4 to 8 maunds yield. The average condition of the crop, wherever it survived, was fairly comparable to that in case of blocks where supply was given at the rate of 45 acres per cusec with drains and better than the area without drains. However an important observation made in this respect was that in majority of the fields the crop failed very badly or was not sown as the supply was insufficient for rice cultivation, (Fig. 7A).

At the representative site of this treatment R. D. 74400-R Mian Ali Branch, an outlet of 1.08 cusec reclamation supply was given for 136.88 acres. Rice was sown in 121 acres or 82.6 per cent. of the entire area. Out of the 100 acres appraised, the crop failed in 12 per cent. area and yielded below 4 maunds in 48 per cent. acres due to low delta of water even though the reclamation supply was supplemented with normal supply by the Zamindar (Fig. 7).

YEAR 1952.

(i) Reclamation supply at the rate of 45 acres per cusec on field drainage basis.

In the blocks under observation 93.2 per cent. area was sown with rice. Less than 4 maunds and 4 to 8 maunds out-turn per acre was received from 9.1 per cent. and 3.8% area, respectively. The remaining 80.3 per cent. area yielded above 8 maunds, (Fig. 8A).

As regards the representative site for this treatment, R. D. 37620-R Mian Ali Branch, full remission was granted to 11 per cent. area, 14 per cent. area received half remission and remaining 75 per cent. gave above 8 maunds yield, (Fig. 8).

(ii) Reclamation supply at the rate of 90 acre per cusec without drains.

In this case whole of the area could not be put under rice because of insufficiency of water supply. The Zamindars tried to sow less area so as to increase the delta for meeting the water requirements of rice. The percentage of area failed or which received half or full remission

(Figure 8A) was, therefore, less in this case as compared to the blocks which received supply at 45 acres per cusec.

In case of the representative site of this treatment, out-let R. D. 62100-R Mian Ali Branch, 1.2 causec reclamation supply was provided for 107·88 acres. Out of these, 100 acres were cropped with rice. Full and half remission was granted to 9% and 6·0% of the area selected, respectively. 77% area gave 8 maunds yield or above. The better growth of crop during 1952 was due to the area having received reclamation supply for one year and the higher supply factor than in 1951 (Fig. 8).

YEAR 1953.

(i) Reclamation supply at the rate of 45 acres per cusec with drains.

In the area, under this category rice was sown in 99% area. 6.6% gave less than 4 maunds and from 2·19% area 4 to 8 maunds yield was obtained. The remaining 90.2 % area gave out-turn of 8 maunds or above (Fig. 9A).

During Rabi 1952-53, 54·4 % of the selected area was put under leguminous crops. In the winter of 1953-54, 55.5% area carried leguminous crops. Lesser Rabi sowing was dué to late maturity of rice crops and absence of proper moisture condition at the time of Rabi sowing.

At the representative site of this treatment, R. D. 37620-R Mian Ali Branch 0·86 cusec reclamation discharge was provided for 38·60 acres for the 3rd successive year. Cent per cent area was put under leaching and sown with rice. 77% gave more than 28 maunds yield per acre (Fig. 9). The remaining 23% gave between 8 and 28 maunds yield per acre. There was no failure and hence no remission. During Rabi 1952-53 and 1953-54, 37 and 36·22 acres respectively were sown with Rabi leguminous crops. No remission was granted in either years as the crop growth was satisfactory.

(ii) Reclamation supply at the rate of 60 acres per cusec without drains.

In this case rice transplantation was carried out in 97·5 % of area selected. 6·8 % of the area selected yielded below 4 maunds. The remaining 90·7 per cent gave above 4 maunds yield (Fig. 9A). During Rabi season 51 per cent area was shown under leguminous crops against 39 per cent in the previous Rabi.

In the case of the representative site of this treatment, outlet R. D. 62100.R Mian Ali Branch, 1·68 causecs reclamation supply was provided for 100·74 acres.. Whole of the area was transplanted with rice. Full and half remission was given to 1 per cent and 3 per cent area respectively. The remaining 96 per cent gave yield of 8 maunds or above (Fig 9).

In Rabi 1953-54, 66.81 acres were put under leguminous crops of which 7·23 acres received full remission, this was due to shallow water-table conditions, hailstorms and heavy rains in the month of February.

CONCLUSIONS.

1. Watertable fluctuations.

The watertable observations during 1951 have shown that during the period of reclamation the maximum rise took place during the months of July and August, which is the period of heavy rainfall. During September the rate of rise of watertable showed a marked fall. The mean rise of watertable upto the end of Septemer ranged from 12 to 31 inches under different conditions. After attaining the maximum level in September the watertable began to recede, with a decline in the rate of recession with each shower of winter rain in the months of November, December and January. The lowest levels were touched in the months of April and May and these were higher than the original levels before reclamation by 12 to 19 inches. During the summer season of 1952 the mean rise in watertable was between 9" and 13" under different conditions which was followed by a fall during the winter months. The lowest level attained after 1952 summer were lower than the level before the reclamation season of 1952 by 5 to 7 inches. This was a year of scanty rainfall and the low rainfall accounts for recession of watertable below the pre-preclamation level. It is thus evident that reclamation supply has very little permanent effect on the rise of watertable. During 1953 with good rains there was rise in watertable compared to the lowest level attained in winter during pre-reclamation period.

During each of the 3 years there was no significant difference in the rate of rise or fall of watertable under different duties of reclamation supply with and without drainage. Had the reclamation supply been responsible for the rise in watertable there would have occured variation in the quantum of rise under different water duties.

The area under reclamation with 45 acres per cusec remained the same during the three years period and in this case there was a net rise of 18 inches in watertable in the first year and at the end of the third year no further rise had taken place. It is thus evident that:—

(i) the rise in watertable during reclamation period is seasonal, and the watertable recedes after the reclamation supply is stopped in each season ;

(ii) rainfall is largely responsible for the rise in watertable ; and

(iii) there is no permanent accretion to watertable during the reclamation cycle after the first year of reclamation operations. Such an accretion does not materially affect crop-productivity of land.

Efficiency of reclamation supply.

(i) In the case of reclamation supply at the rate of 132 acres per cusec, 36 per cent. of the area in 1951 could not be sown with rice (and only 49.8 per cent. of the area gave above 8 maunds of rice), compared to 95.5 per cent. and 78 per cent. for the higher delta of 45 acres per cusec, with and without drains, respectively.

(ii) With 90 acres per cusec of reclamation supply, yield of rice improved, compared to 132 acres per cusec, but the entire area under observation was neither leached nor it could be sown as in case of 45 acres per cusec, which gave a much higher efficiency.

During Kharif 1953 the duty of 60 acres per cusec showed a distinct improvement over the higher duty of 90 acres per cusec, the entire area under observation was put under leaching and the appraised yields compare favourably with the yields obtained from blocks given reclamation supply on the basis of 45 acres per cusec. However, the percentage of area, which gave more than 12 maunds yield in the case of 60 acres per cusec was 47.7 per cent. against 72.5 for the blocks which received reclamation supply at the rate of 45 acres per cusec. It is thus indicated that reclamation supply should be given at the rate of 45 acres per cusec in all cases to get the highest efficiency of reclamation operations. Any higher duty of water than this would give correspondingly low yield of crops. However, where field drainage facilities are not available duty of 60 acres per cusec may be adopted. Although it is a self evident that the removal of saline leachate can only be possible through efficient field drainage system.

Summary.

The progressing menace of salinity has increased the importance of soil reclamation. It has become important to extend the reclamation activity even to high watertable areas, which were left out of reclamation schemes in the past due to the possibily of increasing waterlogging conditions.

It was therefore, felt necessary that some suitable reclamation duty be worked out for the high watertable areas.

The paper describes experiments on the areas having watertable varying within six feet from natural surface. The reclamation duties investigated are 132, 90, 60 and 45 acres per cusec and their effects on watertable with and without drains has been determined. The effect of rainfall has also be correlated with the accretions to the watertable through reclamation supply. The yield of rice crop has been compared to determine the efficiency of various reclamation duties.

As a result it was observed that the water duty of 60 acres per cusecs without field drains compares favourably with 45 acres per cusec with field drains. The reclamation duties of 132 and 90 are insufficient owing to difficulties in bringing the entire area under cultivation as well as incomplete reclamation due to partial irrigation.

It is also observed that :—

(i) During the 3 years there is no significant difference in the rate of rise or fall of watertable under different duties of reclamation supply with and without drainage.

(ii) The rise in watertable during reclamation period is seasonal and the watertable recedes after the reclamation supply is stopped.

(iii) The rainfall is largely responsible for the rise in watertable.

(iv) There is no permanent accretion to watertable during reclamation cycle.

Acknowledgement.

The authors acknowledge with thanks the facilities afforded by Mr. S. M. Saeed (II) and A. W. Pasha Esq., the Superintending Engineers to carry out the experiment in the Lower Chenab Canal East Circle. Mr. Muhammad Iqbal Khan, Assistant Land Reclamation Officer and Messrs M. H. Hashmi and Sher Muhammad, Reclamation Supervisors, gave valuable help in the field operations and recording of observations.

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3. Annual Report of Land Reclamation Department (P. W. D.) for the year ending 1946. Page 17 and 18.

FIG. 1

PART INDEX PLAN

OF

UPPER GUGERA DIVISION L.C.C.(EAST)

SCALE 1" = 4 Mile.

REFERENCES.

Area Under Reclamation 45 Acres Per Cusec With Drains.... ▨

" " " " " Without Drains ▨

" " 132 " " " " ▨

PAPER No 313.

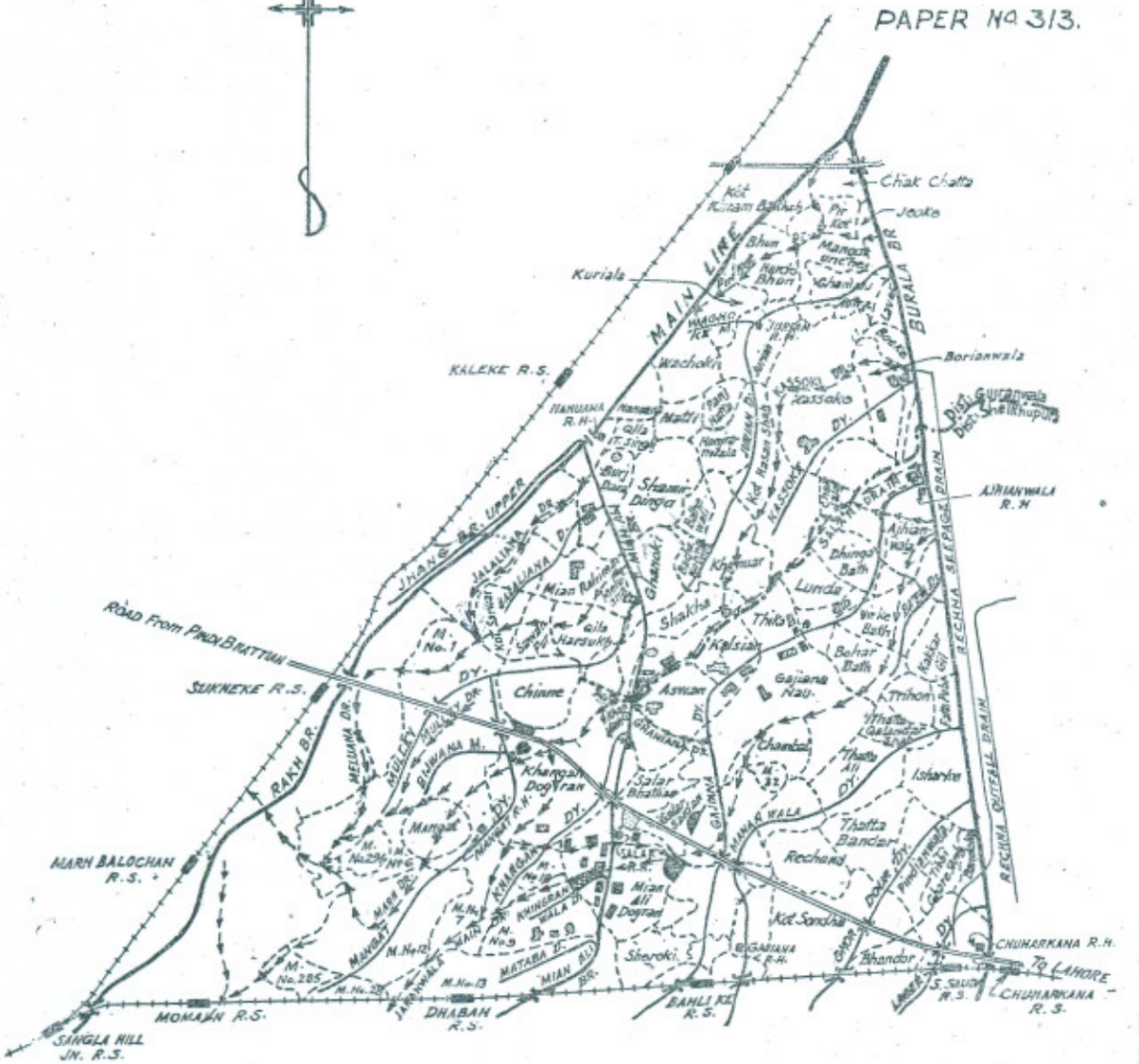


FIG: 2 PAPER NO. 313

PART PLAN VILLAGE KHANKAH DOGRAN SHOWING RECLAMATION BLOCK AT R.D.90-R ON MIAN ALI BRANCH.

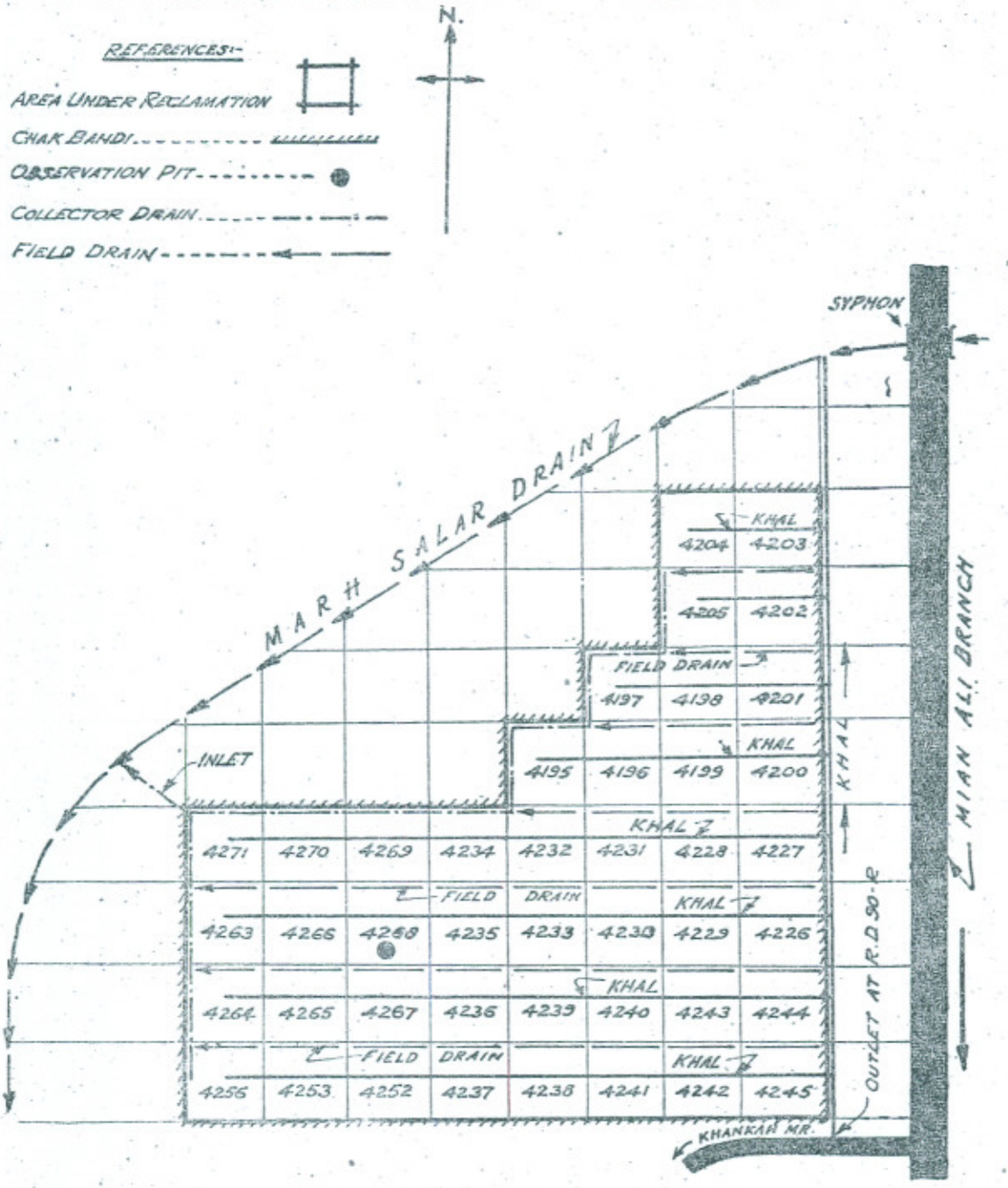
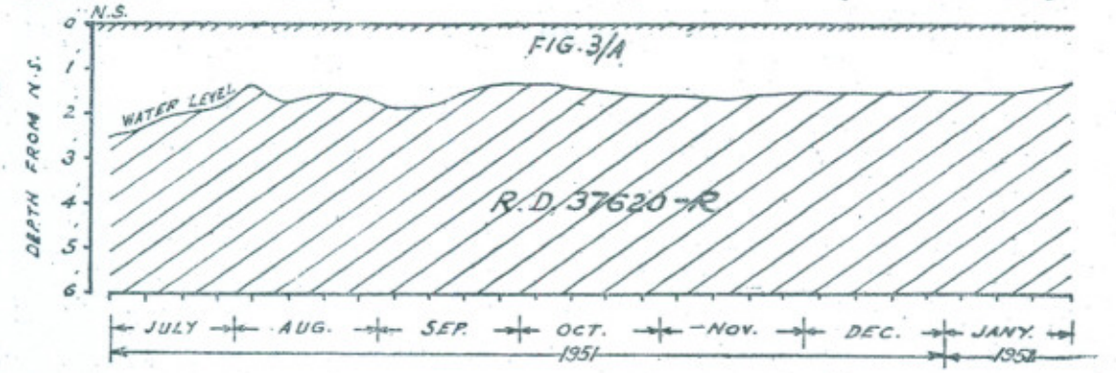
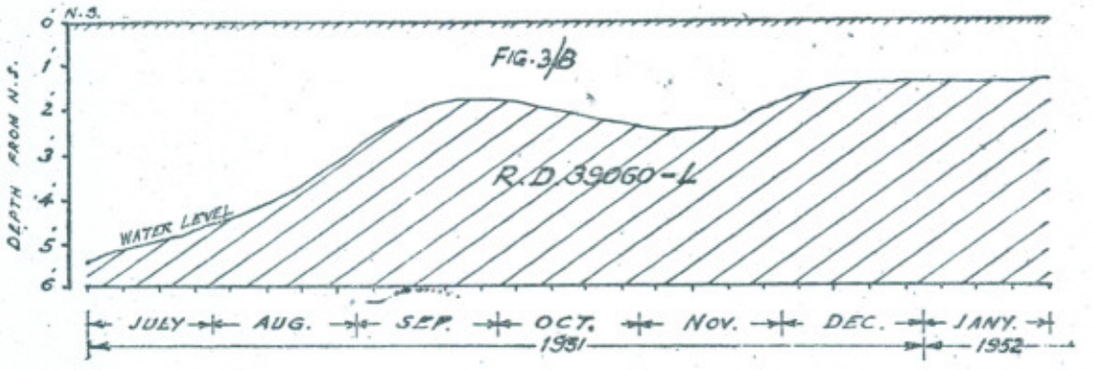


FIG. 3 PAPER NO. 313.

WATER TABLE OBSERVATIONS IN THREE BLOCKS UNDER VARYING CONDITIONS OF WATER SUPPLY ON MIAN ALI BRANCH (L.C.C. EAST)





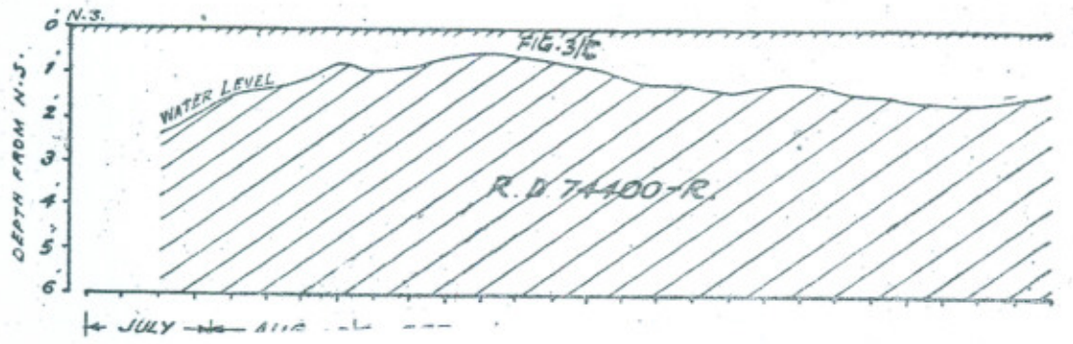


FIG:4 PEPER No. 3/3.

SHOWING WATER TABLE OBSERVATIONS OF BLOCKS UNDER VARYING CONDITIONS OF WATER SUPPLY ON MIAN ALI BRANCH (L.C.C. EAST).

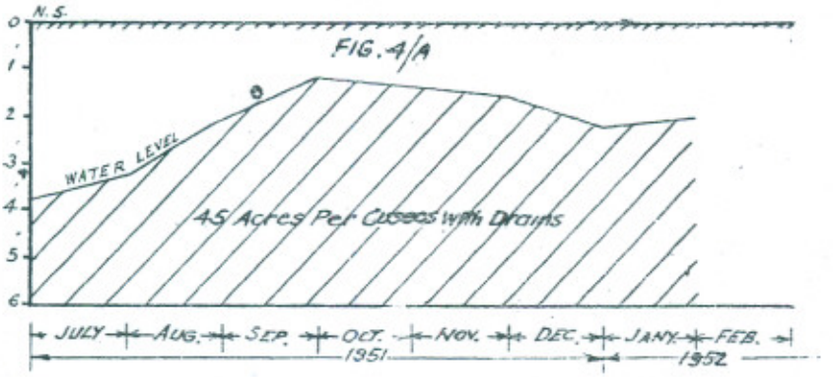


FIG. 4/A

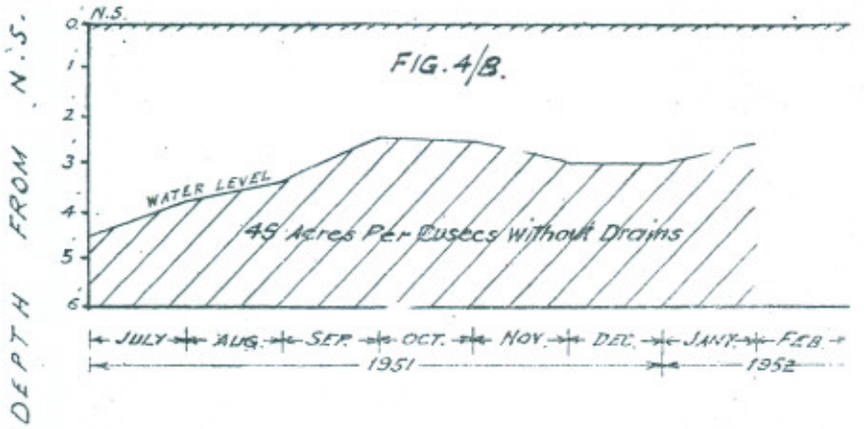


FIG. 4/B.

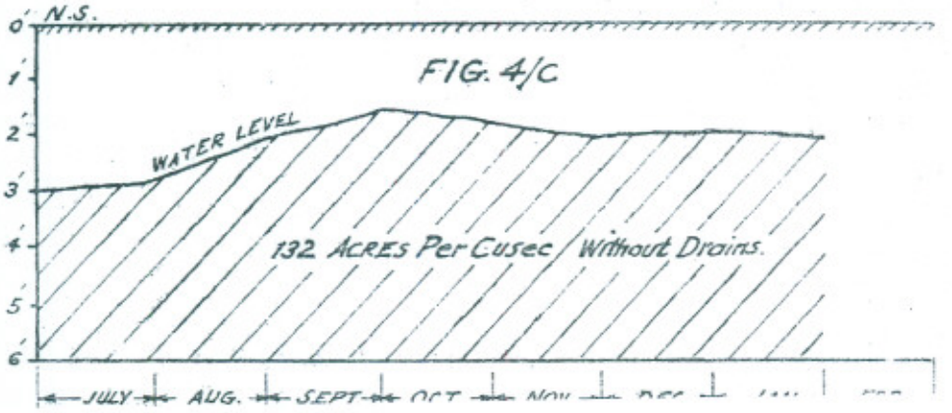


FIG. 4/C

FIG:5

SHOWING WATER TABLE OBSERVATIONS OF 2 BLOCKS UNDER VARYING CONDITIONS OF WATER SUPPLY ON MIAN ALI BRANCH (L.C.C. EAST) FROM JULY 1951 TO MARCH 1954.

FIG.5/A

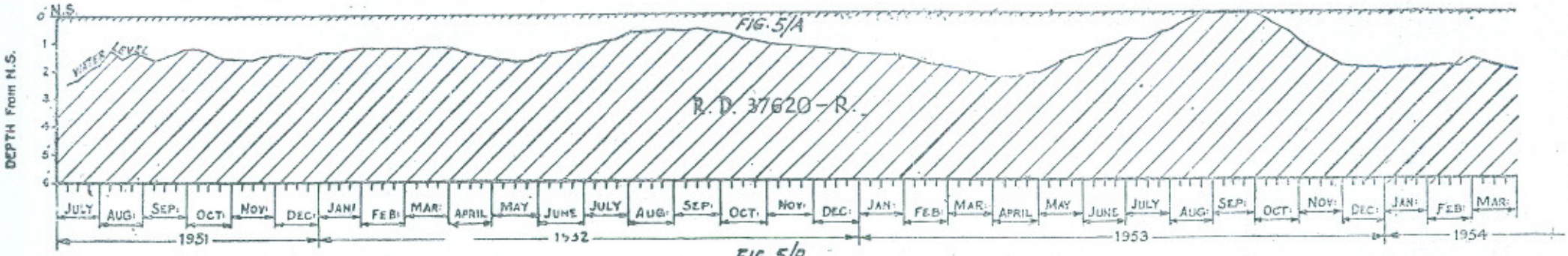


FIG.5/B

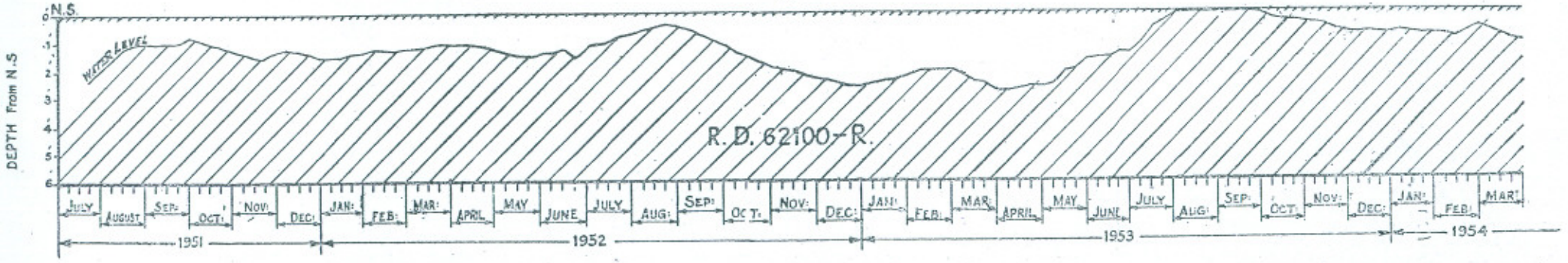


FIG: 6

SHOWING WATER TABLE OBSERVATIONS OF BLOCKS UNDER VARYING CONDITIONS OF WATER SUPPLY ON MIAN ALI BRANCH. (L.C.C. EAST) FROM FEBRUARY 1952 TO MARCH 1954.

FIG. 6/A

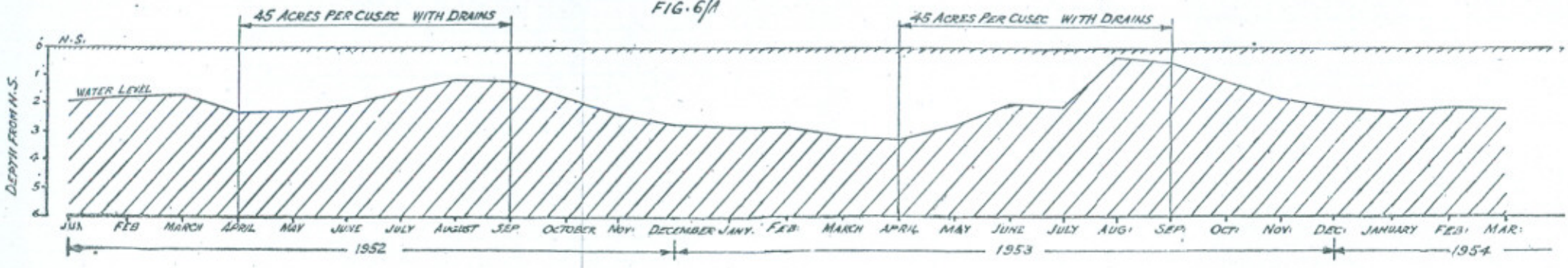


FIG. 6/B

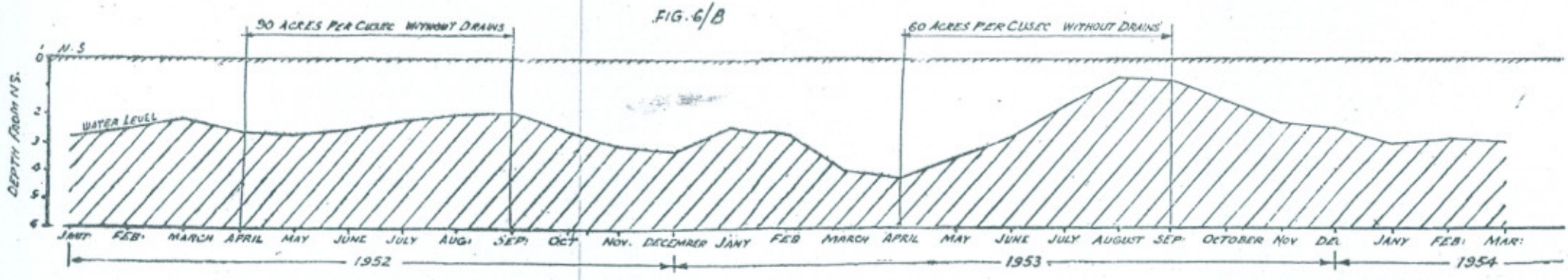


FIG:7 PAPER NO. :

SHOWING PROGRESS OF RECLAMATION IN 3 BLOCKS .
VARYING CONDITIONS OF WATER SUPPLY ON MIAN ALI .
(L.C.C. EAST) 1951
(PERFORMANCE & RICE APPRAISEMENT.)

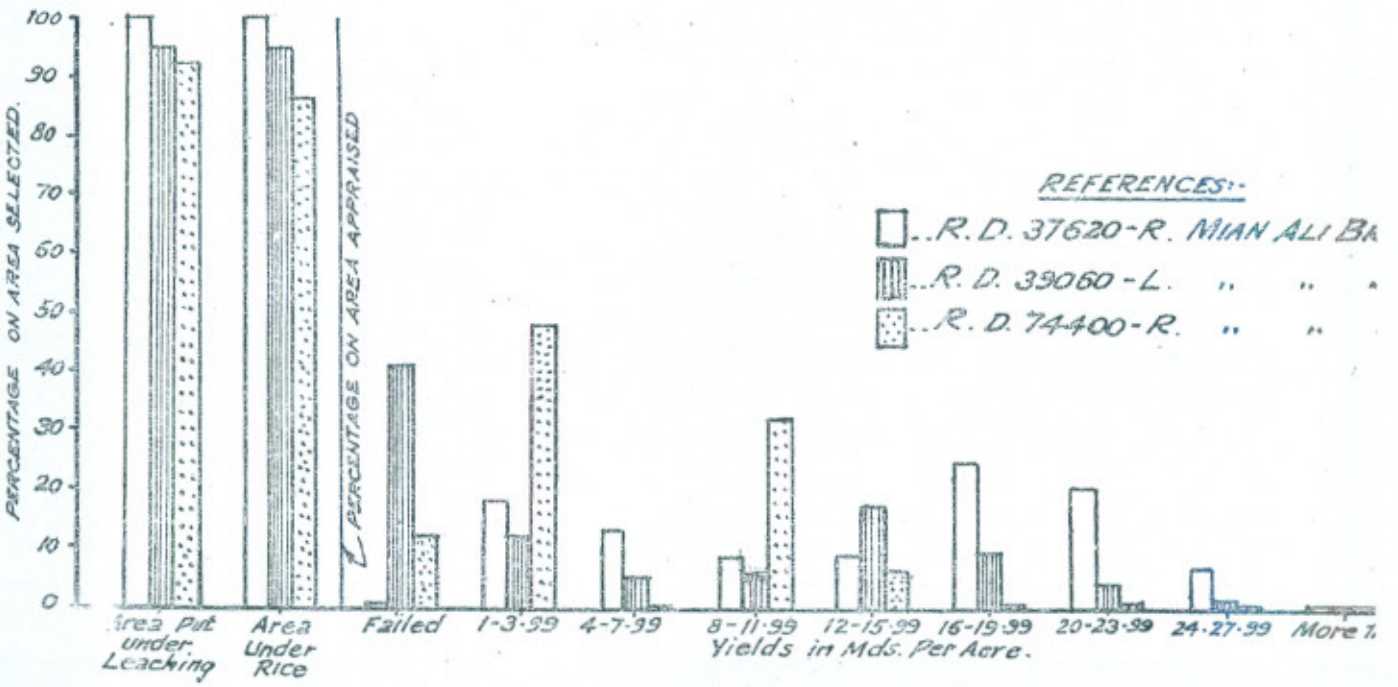
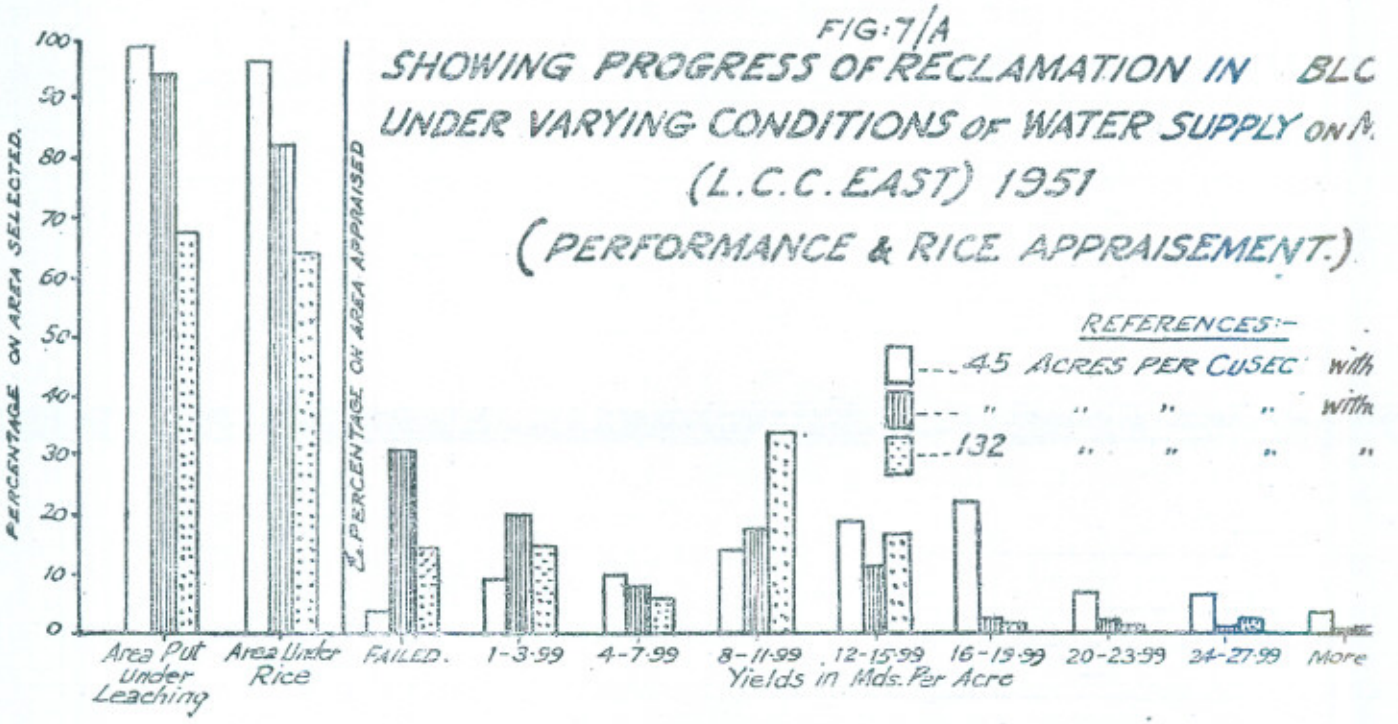


FIG:7/A

SHOWING PROGRESS OF RECLAMATION IN BLC
UNDER VARYING CONDITIONS OF WATER SUPPLY ON M.
(L.C.C. EAST) 1951
(PERFORMANCE & RICE APPRAISEMENT.)



PAPER NO

FIG: 8

SHOWING PROGRESS OF RECLAMATION IN 2 BL
UNDER VARYING CONDITIONS OF WATER SUF
ON MIAN ALI BR: (L.C.C. EAST) 1952.
(PERFORMANCE & RICE APPRAISEME

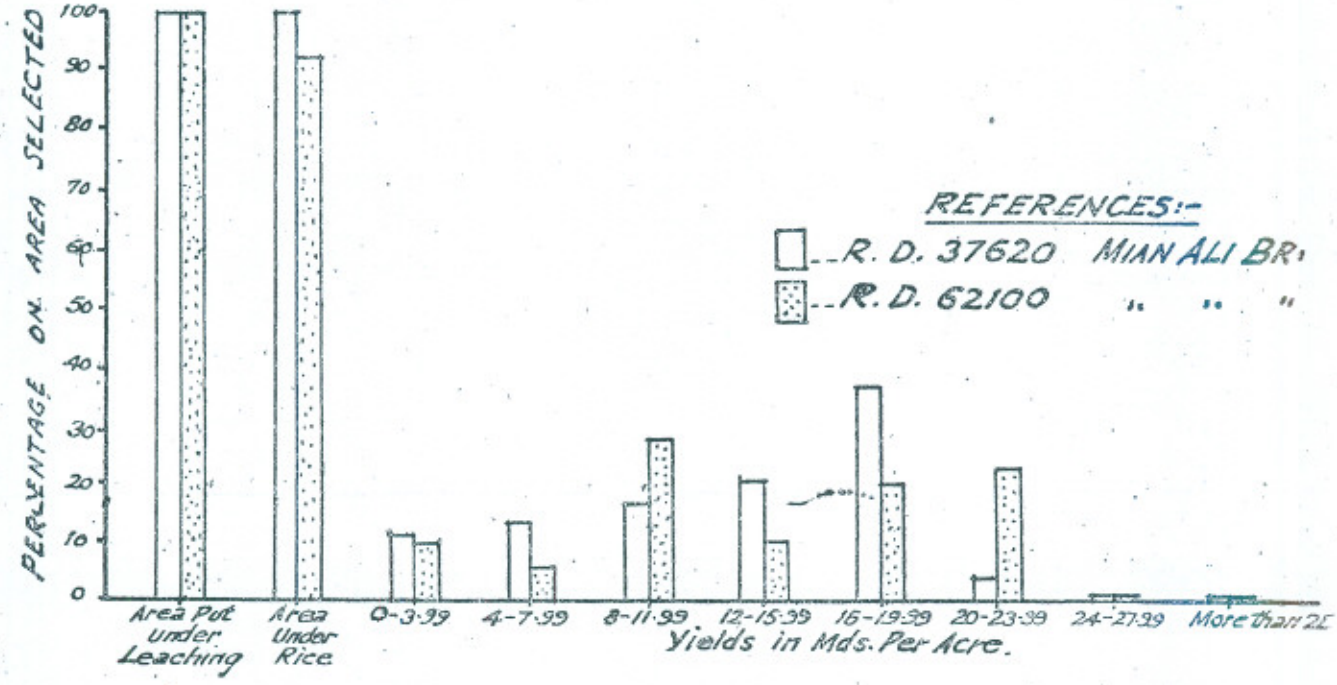


FIG: 8/A

SHOWING PROGRESS OF RECLAMATION IN BL
UNDER VARYING CONDITIONS OF WATER SUF
ON MIAN ALI BR. (L.C.C. EAST) 1952.
(PERFORMANCE & RICE APPRAISEMENT.)

