

A STUDY OF THE INTERNAL ECONOMY OF WATER
AS PRACTISED BY ZEMINDARS ON AN OUTLET
ON THE UPPER BARI DOAB CANAL.

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Introduction.

In past years a considerable amount of time and money was spent in studying how zemindars utilize the water supplied from a canal on their land. It is of considerable importance to canal engineers to know with accuracy the quantity of water which a farmer considers is required for each crop, and also to know how many times a farmer desires to water a crop and the month during which a crop is sown. Observations of the internal distribution of water on an outlet have been made from time to time for the last 25 years. Speaking from memory Mr. Woods, Chief Engineer, in 1919 when reviewing the results said that the large amount of time and money spent on these observations has not given any tangible results. Last year it was decided to try once again to get first hand knowledge of the above by making a detailed daily record of the use of water on an outlet.

In order to know the real mind of cultivators it was necessary to select an outlet that had a good supply of water, so that the cultivators should be able to sow their crops when they desired without being hampered by a restricted water-supply.

The object of this paper.

It is possible to obtain information from publications on all matters of purely engineering interest, but as far as the writer knows there is no paper from which a canal engineer can learn how to carry out his maintenance and repairs so that the least amount of inconvenience should be caused to the cultivators, and the least amount of revenue lost to Government, and also how to tackle defects in channels under his control. Engineers may sometimes think that the construction of a canal is the be-all and end-all of an engineer's duty. Actually a canal engineer's work really commences after the canal has been built, and it is hoped that by bringing out the results obtained from a study of the internal economy of water on an outlet he may be able to avoid doing things that result in a loss both to the cultivators and to Government revenue.

The experiment itself.

Two canal observers were appointed to live at the site of the outlet chosen for observations. Their duties were as observers only. They did not interfere in any way with the distribution of water. They had to note the day and time in which each field was given a watering, the exact period of time each watering lasted, the day on which the crops were sown together with the name of each crop and the area of each field.

They were supplied with stop watches so that the time water flowed on each field was accurately observed. The discharge flowing in the outlet and in the watercourse was observed daily. They were provided with registers to enter all the information noted above from time to time and these registers were inspected frequently so that one could see whether the work was being done methodically and carefully. The rainfall was also noted. The mass of statements collected as a result of these observations was large and unwieldy, and it was necessary to abstract the results obtained from these statements in a convenient form to be understood easily.

Results obtained from experiments.

Before discussing the results obtained it is necessary to explain the principles on which the results were abstracted.

- (a) The raoni or first watering of a crop is accepted as water that earns revenue.
- (b) In the diagram a crop has been shown as sown during the month in which it received its last raoni watering. It was occasionally found that certain fields received repeated raonis over a period of months before a crop was actually sown. In such cases a crop is shown as sown on the date it received its last raoni, e.g., a field of rice received its last raoni on the 28th of July and the crop actually sown on the 7th of August. The area of this field is shown as sown in July and not in August.
- (c) In the diagram all fodder crops have been lumped together and shown as fodder.

An attempt has been made to bring out the results in the form of a statement and of a diagram.

In the diagram against the various months of the year has been plotted the total daily supply of water used in the outlet and the area of the various crops sown during the month. At the bottom of the diagram is shown the percentage of the total water earning revenue during each month on the outlet. This percentage has been obtained by dividing the water used for raoni by the total water supplied to the outlet during the month, e.g., in the month of September the revenue earning water is shown as 37%. This means that 37% of the total amount of water that was supplied to the outlet during September was used for sowing crops. The balance of 63% was used for watering crops that had already been sown.

The statement attached shows the total amount of water in c.ft. supplied to the outlet during each month. It also shows the number of c. ft. of water that was used for raoni, i.e., the revenue earning water. It also shows the total area of all crops sown during each month and the total *abiana* or water rate that was obtained by Government for the crops sown each month and also the value of a thousand c.ft. of water in annas each month.

Statement of Results obtained from Crop Experiment.

Months.	Total crop acres.	Total water in cubic feet.	Water that earned revenue cubic feet.	% Water that earned revenue.	Total water rate in rupees.	Value in annas of 1000 c. ft. water.
September ..	42.46	16,23,924	6,05,741	37.3	180.18	1.77
October ..	98.98	13,33,086	12,47,735	93.6	470.93	5.65
November ..	24.60	6,95,287	2,37,587	34.2	86.62	1.99
December ..	16.30	5,21,879	2,35,387	45.1	29.31	0.89
January ..	2.20	4,66,968	30,876	6.6	8.93	0.30
February ..	6.82	17,86,042	94,365	5.3	25.63	0.32
March ..	7.41	15,65,563	1,87,304	12.0	41.88	0.43
April ..	35.50	8,83,619	7,89,719	89.4	175.62	3.18
May ..	39.31	13,55,172	10,23,577	75.5	121.93	1.44
June ..	20.80	11,76,658	4,29,306	36.5	55.5	0.75
July ..	4.32	3,68,078	1,47,500	40.1	22.56	0.98
August ..	10.26	8,10,058	1,35,372	16.7	46.50	0.92

Internal economy of an outlet.

To understand the statement and the diagram details are explained below for the month of September.

The total of the area of the various crops shown in the diagram will equal the area of all crops shown in the statement. In the statement, if 6,05,741 c.ft. which is the water that earns revenue is divided by 16,23,924 c.ft. the total water supplied to the outlet during the month the result will be 37%. Again in the statement, if Rs. 180.18 is divided by 16,924 c.ft. of water this will give 1.77 annas as being the value of a thousand c.ft. of water.

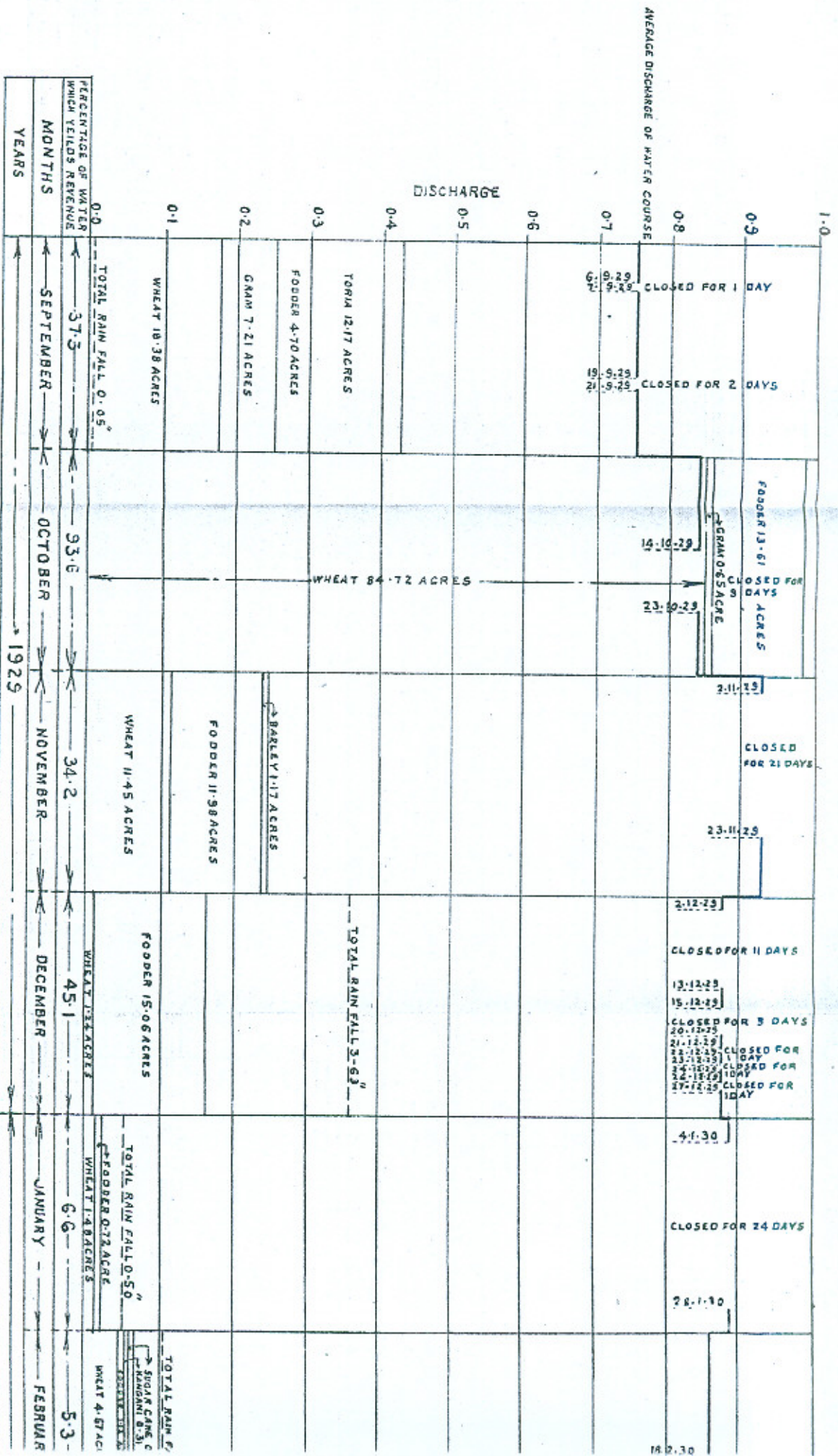
Deductions obtained from the diagram and statement and some suggestions.

For the winter crops the diagram shows that *Toria* receives its first watering in September, wheat in October and November, winter fodder crops in October, November, and December, and that a certain amount of rain sown wheat becomes canal irrigated in January, February, and March.

For the summer crops the diagram shows that cotton gets its first raoni in April and May. Fodder crops are sown principally in May and June. Sugar-cane is sown in March, and rice in July. Probably the most interesting item is the percentage of water that earns revenue during each month. One sees that in October 94% of the total water received was used for sowing crops, and in April 89%, and in May 75%. From a revenue earning point of view the four slack months are January, February, March, and August. In the month of March the demand is keen but the greater portion of water is used for maturing winter crops. It is thus seen that August, January, and February are the three months during which closures can be made with a least amount of loss, and that October is certainly not a month when any channel should be closed. Yet it is well-known that during the months of October and November distributaries are often closed to effect silt clearance owing to complaints from zamindars of short supplies in the tail reaches. During the summer months owing to the large silt content of water many of the smaller channels silt to a greater or lesser extent. The ideal of course is to have regime channels that do not silt. In practice owing to unfavourable land slopes and other causes it is not possible to achieve this result and the fact remains that some channels do silt. An inexperienced Sub-Divisional Officer waits until the cultivators complain of short supply before he attempts to put such channels into good working order for the winter. The result is that during October and November in such a Sub-Division there is a considerable outcry from cultivators, and the Sub-Divisional Officer has to hurriedly close certain channels and silt clear them. Such closures are effected often in October, and are a definite loss of revenue to Government, and also a very serious loss to the unfortunate cultivators who are unable to sow their crops. It may be argued that in October the supply in the river is less than the requirements of the canal and if one channel is closed, the water can be used elsewhere. This is true to a point, but it should be remembered that to

get the maximum revenue, distribution of water must be done with the maximum degree of equality, and if too much water is given to one area and too little water to another, the extra revenue from the first area will not equal the loss from the second area. Leaving aside this point it should be one of the first concerns of the Canal Department to so distribute its water that the cultivators who are dependent upon this water for their livelihood and happiness are put to the least amount of inconvenience and suffering.

It is no exaggeration to state that October and November are the two months in which most silt clearance is done, because Sub-Divisional Officers do not take up the question of silt clearances sufficiently early in the year. The proper time to do silt clearances for the winter crop is early September. To get silt clearance done it is necessary to have a survey and estimate prepared. This work is frequently left to the time when complaints are received for short supply, *i.e.*, till October. The mistakes in this respect made by Sub-Divisional Officers are not confined merely to the inexperienced. An experienced Sub-Divisional Officer may take over a Sub-Division in April. He does not know which of his distributaries are going to give trouble in October and the transfer notes of the relieved Sub-Divisional Officer will very seldom point this out to him. It requires a keen man to busy himself to such an extent from April to August that he shall find out which of his channels will require treatment before October comes. Therefore it is a question whether it should not be ruled that the transfer notes of the relieved Sub-Divisional Officer should specify such channels. The Canal Sub-Divisional Officer should realize that if he works methodically during the summer, he will have a very much easier time during the winter, and the added satisfaction of knowing that the cultivators on his channels are as prosperous and contented as it is within his power to make them.



NOTE
 PERCENTAGE OF WATER IS ARRIVED AT BY DIVIDING TOTAL SUPPLY OF
 TO THE QUANTITY OF WATER UTILIZED FOR NEW CROPS WIDE STATEMENT

PER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL
93.6	34.2	45.1	6.6	5.3	12.0	89.4	
WHEAT 84.72 ACRES	WHEAT 11.45 ACRES	WHEAT 12.2 ACRES	WHEAT 1.4 ACRES	WHEAT 4.67 ACRES	WHEAT 0.31 ACRES	WHEAT 0.31 ACRES	
FODDER 13.61 ACRES	FODDER 11.58 ACRES	FODDER 15.06 ACRES	FODDER 1.4 ACRES	FODDER 1.28 ACRES	FODDER 1.28 ACRES	FODDER 1.28 ACRES	
SERMINGO SACKE							
BARLEY 1.17 ACRES					SUGAR CANE 0.72 ACRES	SUGAR CANE 3.96 ACRES	
MAHI 1.55 ACRES					MAHOGANI 0.31 ACRES	MAHI 1.55 ACRES	
COTTON 3.24 ACRES							
15.18-29	23.11-29	13.12-29	15.12-29	19.12-29	18.2-30	16.4-30	
CLOSED FOR 2 DAYS	CLOSED FOR 21 DAYS	CLOSED FOR 11 DAYS	CLOSED FOR 9 DAYS	CLOSED FOR 24 DAYS	CLOSED FOR 1 DAY	CLOSED FOR 1 DAY	
15.18-29	23.11-29	13.12-29	15.12-29	19.12-29	18.2-30	16.4-30	
WHEAT 13.61 ACRES	WHEAT 11.45 ACRES	WHEAT 12.2 ACRES	WHEAT 1.4 ACRES	WHEAT 4.67 ACRES	WHEAT 0.31 ACRES	WHEAT 0.31 ACRES	
10.9-10	12.9-10	15.9-10	18.9-10	21.9-10	24.9-10	27.9-10	30.9-10
CLOSED FOR 2 DAYS	CLOSED FOR 21 DAYS	CLOSED FOR 11 DAYS	CLOSED FOR 9 DAYS	CLOSED FOR 24 DAYS	CLOSED FOR 1 DAY	CLOSED FOR 1 DAY	

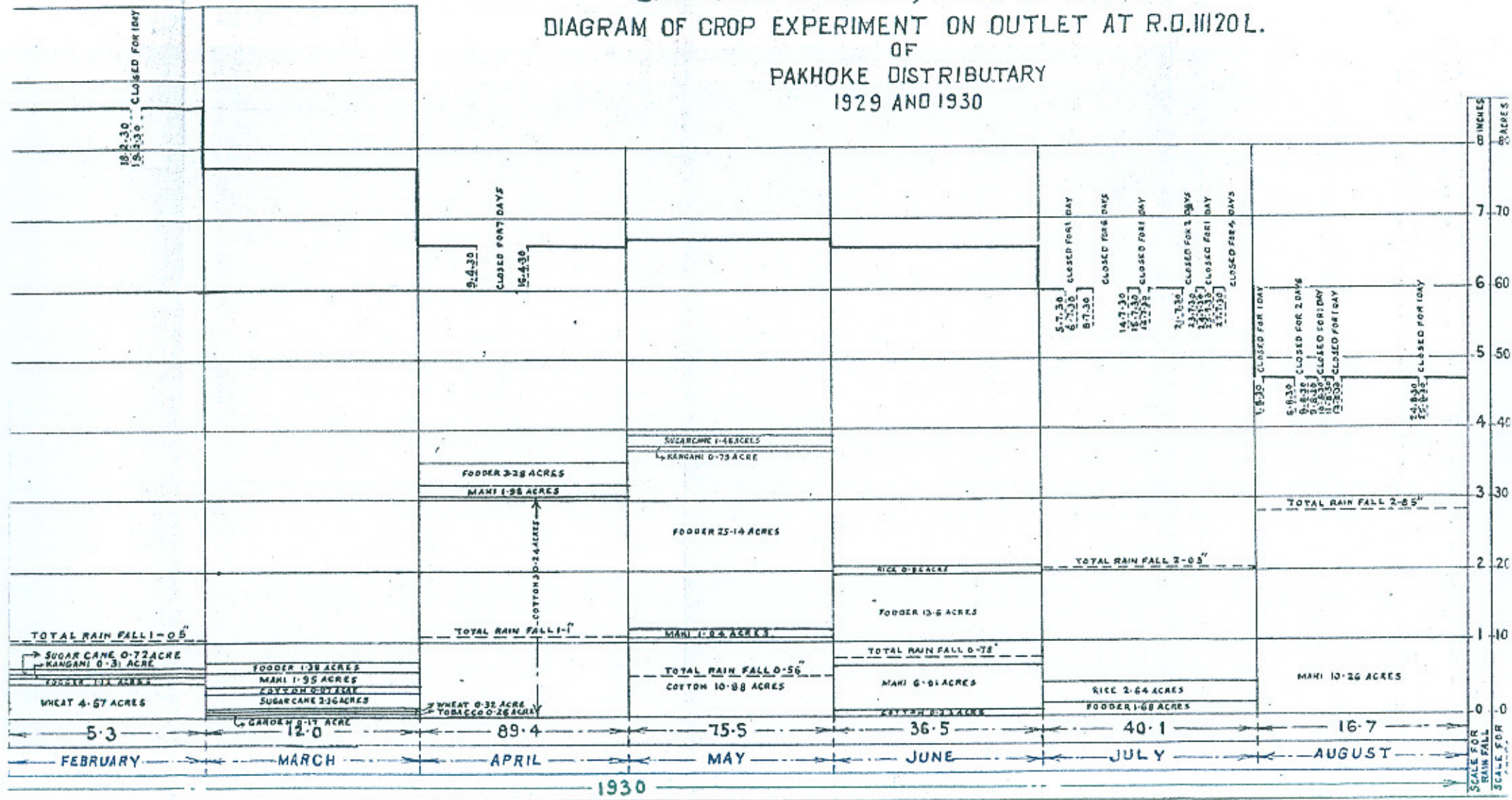
NOTE

PERCENTAGE OF WATER IS ARRIVED AT BY DIVIDING TOTAL SUPPLY OF WATER DURING THE MONTH TO THE QUANTITY OF WATER UTILIZED FOR NEW CROPS WISE STATEMENT ATTACHED.

JANDIALA DIVISION, U. B. D. CANAL

DIAGRAM OF CROP EXPERIMENT ON OUTLET AT R.D. III 20 L.

OF PAKHOKE DISTRIBUTARY 1929 AND 1930



TOTAL SUPPLY OF WATER DURING THE MONTH
5 VIDE STATEMENT ATTACHED.

SUPERINTENDING ENGINEER
UPPER BARI DOAB CIRCLE

MR. BEDFORD in introducing his paper showed a diagram of the result of the observations and explained that the outlet on which these experiments or observations were made was one with a good supply of water, so that the zemindars could do their cultivation when they wanted to. The results showed that as far as the zemindars were concerned they sow toria crop in the month of September, wheat in October and November and cotton crop in the months of April and May. These were the three principal crops sown. In Europe there were two periods for sowing wheat winter and spring. He believed that the winter sown wheat was in greater favour than spring sown wheat and gave a better outturn, the reason being that it had a longer period to grow and mature. The maturing season was fixed by climatic conditions hence it was not feasible to put forward or set back the natural sowing period for crops. The results obtained also went to show that you cannot sow your cotton successfully in the month of June and as the supply of water in the months of April and May was deficient it showed to a great extent why the S.V.P. was not likely to pay its way.

MIAN IQBAL HUSSAIN remarked that Mr. Bedford should be thanked for taking the trouble to write a paper on a subject which had been shelved since 1918. Heavy expenditure had been incurred on the crop experiments started by Mr. Woods. Anyhow this paper has come to us with a bold heading of economy, which is now becoming a household word. Mr. Bedford, in fact, wants to tell us how the zemindar will become economical, when we sell the water in bulk to him. He may decline to take water from us during January, February, March and August and therefore for fixing the value of the cusec we should keep this point in view.

This paper should certainly have been contributed earlier, in fact before we took in hand the Sutlej Valley Project. We would have known definitely that it was April and May water which serves the land and earns the revenue during kharif and not the record floods of August and September. From the data supplied to us by Mr. Bedford we would not recover the full value of water which may be stored during August and September for use during April, May and June in the contemplated storage schemes. The Revenue Manual in use also needs overhauling, where the dates for sowing season are given. For instance, the Revenue Manual gives for cotton February to July, while Mr. Bedford gives April and May, and we all know that in this respect the Revenue Manual is too slack, and late sown crops give less yield.

There is one point which is of particular interest, *viz.*, the advice for fixing period for silt clearance.

In 1919 when I was in charge of Jhang Division, the order before me was no channel is to be silt cleared even if the tails do not receive any water. For sometime I did respect this wish of my predecessor, but later on I had to revolt. I curse the day when the word 'Regime' en-

tered into our vocabulary. No earthen channel carrying varying silt charges can ever acquire regime condition, and to make the poor zemindar suffer under the garb of such deceiving terms is nothing but a farce, and Mr. Bedford's advice should be strictly followed for a regular programme of silt clearance what had been our practice in the old days.

MR. B. L. UPPAL remarked that the paper shows clearly for each month of the year, the revenue earning quantity of water and then deduces slack months so far as revenue earning capacity of water is concerned. These slack months are January, February, March and August. But as the author himself points out March should not be treated as a slack month, as demand is keen for maturing the rabi crop, although the percentage of water which earns revenue in this month is 12.0 only.

According to the author there should be no closures in the months of October, November and December. The diagram, however, shows that the outlet was closed for 9 days in October, 21 days in November and 19 days in December, in spite of high revenue earning power of water in these months. Every Engineer, however, knows that although first watering for most of the wheat crop is done in October, we cannot have a good crop without *kor* watering, and then second and third waterings for maturing. Thus for wheat the *kor* watering and maturing periods are as important as the sowing period and therefore it is incorrect to call January, February and March as slack months. If no *kor* watering is done, the crop is bound to fail and will bring no revenue.

Slackness of demand for water, as is commonly understood is best shown on the diagram by the average discharge of the outlet in each month. Thus the only slack month both from the point of view of revenue earning power of water or the keenness of the zemindar to keep his water-course clear is August. Does the author then mean that all silt clearance should be done in August. In the last paragraph he, however, suggests early September, although the revenue earning power of water in this month is more than twice that in August. August is hardly a suitable month for silt clearance of a channel as demand for water is slack and the channel is liable to silt up again. September is certainly better, but the best time will be during the first rotational closure of the channel in September or October.

As regards the suggestion for transfer notes of the Sub-Divisional Officer, I think an average Sub-Divisional Officer will mention channels requiring attention without any special rules. Moreover, the subordinates are expected to mention every month on their T. A. Journals what channels are in bad order and in some circles, the Sub-Divisional Monthly Progress Report is also expected to show channels requiring attention.

The paper thus deals with the problem of the best time for closing a channel for purposes of maintenance and repairs and gives value of

revenue earning water for different months. It would be useful if experiments were carried out to gain knowledge of other aspects of the internal economy of water.

MR. COLYER stated that his remarks were not really very strictly on the paper itself, but more upon the subject in general. He stated that the crop experiments that were being made, were inclined to be sidetracked because they are made by the patwari, and the extremely interesting results derived by Mr. Bedford justified a much stronger interest being taken in the observations that were being made elsewhere.

He observed that when the report of these experiments was sent to the S. R. O. to make some use of it, he took the opportunity of investigating the observations and gained an enormous amount of knowledge.

The speaker's point was that these observations if they were going to be pushed into S. R. O.'s office and if they are going to be used they ought to be treated seriously. He went on to say that another very interesting thing that he came across was the value of sugarcane showed Rs. 150 an acre compared to other crops no one of which was more than Rs. 13. When he investigated this he found out that the sugarcane crop had been watered half by irrigation and half by well waters, but no account had been taken of the latter watering. This sort of thing would lead to an entirely wrong value given to sugarcane in the home of the Pandits in Lahore.

MR. ROBERTS remarked that each man should stick to his trade and from that point of view he should like to say that this paper and the other paper read that morning regarding the control of floods were the two papers that interested him most in this Congress. Mr. Bedford method's were very fair ones and in his opinion in all the work as in this paper the aim should be to get to know the facts. He wished, however, to state that when Mr. Bedford started to draw conclusion he was, in his opinion going astray, for even assuming that the conditions of this minor were typical for that canal, they could not have been so for the whole of the Irrigation Branch, and the facts would be very different on other canals.

He thought that it was a dangerous thing to assume that the Raoni or first watering was the earning power of the canal. Actually if you take this for granted then your charges for wheat should be the same as for this commodity on non-perennial canals. Then the land revenue, a part of the earning power, will also have to go down. He went on to show that the last watering was the most important one as far as the yield was concerned. He remarked that February was one of the most important months possibly, in some parts of the Province, from the 20th January to 15th February, for the watering of wheat. August and September were the most important months for cotton, and in this respect it would be a definite loss if the canal is closed when there is water available in October and November.

In replying to the criticisms on his paper MR. BEDFORD said Mian Iqbal Hussain's speech on my paper has further brought out a point which is of great importance in the making of a Project estimate. All earlier Project estimates have been great financial successes. A Project estimate consists of two parts, an estimate for the cost of the work, and an estimate of the probable revenue earned by the work.

It so happened that the rivers from which water was taken for the earlier canals had a good supply of water during the kharif and rabi sowing seasons. The method of averages of supplies in the river over a period of months employed in making the estimates of receipts on our earlier Projects was unsound, but as the rivers had good supplies during the sowing seasons, Projects paid their way though the estimates of returns were not accurate. In the earlier Projects there was some excuse for this faulty method of estimating, but with our yearly experience we should have had data showing the value of water each month in the year. It was due to, or not realising the fallacy of, our former methods of calculating revenue receipts that a large portion of the blame for the very incorrect Project estimate of the Sutlej Valley Project Canals is due. In future Projects it will be essential to know with accuracy the quantities of water we are likely to have during the months for sowing crops. We can obtain accurate values for such water on our existing canals by continuing these crop experiments with that object in view. Then knowing the quantities of water that we may expect during the sowing season and knowing the value of that water we can estimate the probable revenue returns on a Project with a far greater degree of accuracy than has recently been the case. The revenue returns we would get under the above method of calculation would be the maximum and would be subject to there being sufficient water during the growing and maturing season of the crops concerned. It will, therefore, be necessary to know accurately the supply of water that will be available in the river for each month of the year separately. Averages have no place in such an estimate. You know the old story of a traveller sitting on the banks of a river with his family and children of various heights. He is a poor man; he cannot afford the price demanded by the ferry so when the ferryman is poling across the river he observes the depth of water at the various points. He is also somewhat of a mathematician and he strikes an average for the depth of the river and finds it $2\frac{1}{2}$ feet. He then makes his family walk across the river one by one. Height of the smallest child is 3 feet. Unfortunately the river at its deepest point is 6 feet, and all his family gets drowned. He then takes out his sheet of calculations and checks them again and remarks as follows :—

“My calculations are undoubtedly correct, but still my whole family are drowned.”

Project estimates of receipts based on averages are similarly liable to meet with disaster.

Mr. Uppal has not clearly grasped the meaning of this paper. We first of all consider the internal economics of water distribution on an outlet. Having obtained the results we try and deduce suitable periods or silt clearance where required, and also try and evolve a better method of estimating the revenue returns in a Project. It is clear that unless you have water during the sowing season no amount of water in the other months will bring you any revenue. It does not mean that water during the growing period is not required, it is essential and in a Project we should see that such water exists, but it has no place in the calculation of revenue that is likely to be earned except to show whether our Project estimate based on water available during the sowing season should be reduced. He further says that there should be no closures in the months of October, November and December. By this was meant no closures for purposes of silt clearance. Where closures of the distributary in question occurred they were due to insufficient water in the river, and were, therefore, unavoidable. Silt clearance during rotational closures should of course be done, but we should not postpone the silt clearance to so late a date that the crop sowing season is wholly or partly passed away before silt clearance is affected.

The author entirely agrees with Mr. Colyer in saying that these crop experiments should be treated seriously. In fact he believes that they should form a regular part of our Research Department's duties, so that we shall have reliable data regarding the value of water during the various months of the year.

The author agrees with Mr. Roberts that the conditions on this particular outlet will not be the same as exist on the various canals in the Punjab. It is, therefore, all the more necessary that similar experiments should be regularly made on every canal in the Punjab to find out the value of water in each month on the various canal systems. Such information would be invaluable in calculating the revenue earning capacity of any Project. Mr. Roberts' deduction that if the Raoni watering gave the earning capacity of the canal the rate charged for first watering should be the same for wheat on non-perennial canals. The lesser rate charged in the latter case is probably due to the belief that the want of water to mature the crop would result in a smaller average outturn, and no doubt this is true, but Mr. Roberts has missed the point which I have tried to make, *viz.*, that in making a Project estimate you must base your estimate of maximum earning capacity on the water in the sowing season. This estimate of course may require to be reduced if there is not sufficient water to mature, but it can under no circumstances be increased by taking an average of water supply in the river over a period of months. Mr. Roberts' remarks regarding the effect of water on the yield of a crop during the various months of the sowing season are fully admitted, but if the zemindars had not the water during the sowing season there would have been no crop to mature.