SOME NOTES ON IRRIGATION

By T. G. CLEASBY

This paper attempts to discuss certain aspects of irrigation on the basis of limited information which has been gained at Tongaat during the past few years. The ideas put forward may or may not be agreed with, but if they stimulate interest and discussion on the numerous problems and unknowns, which arise from the application of water to sugar cane, then this paper has served its purpose.

The word irrigation has come to mean the controlled application of water to the land, that is, specific quantities of water at planned times, and any application of water which falls short of these objectives requires another word to describe it. There are two methods of irrigation—surface or furrow irrigation and overhead, spray or sprinkler irrigation. It is important to realise that either can be the right way to irrigate. Where the land is gently sloping and water abundant and cheap, furrow irrigation must be considered first and foremost. When the terrain is difficult and, in particular, water scarce or expensive, then overhead irrigation comes into its own. It is for precisely these reasons that overhead irrigation has been developed at Tongaat.

Although the following conclusions relate to overhead irrigation, the principles involved apply equally well to furrow irrigation governed only by the practical difficulties of applying precise quantities of water at each application.

Response to Irrigation

Up to the present time only a few experiments have been carried out to study the response to the overhead irrigation of sugar cane in Natal. It is interesting to examine the results which are available if, at the same time, the limited confidence which can be placed on them is also borne in mind.

In addition to the experiments at Tongaat, the Experiment Station has results from one unreplicated trial over plant cane and four ratoons and at Illovo Sugar Estates the results from the plant cane crop of a very critical trial which was harvested in August 1959.

These experiments have all been carried out on shale soils, mainly shallow, with above average levels of fertiliser and irrigated to ensure that the cane suffers a minimum of moisture stress. Other soils would almost certainly give different responses to irrigation, but irrigation must first be considered for soils which are most prone to droughts and these undoubtedly are the shallow shales. It would require a relatively low duty of water to enable the experimental applications of water to be applied in the field. In the Tongaat experiments, water applications were based on evaporation data and would have required no less than 1 cusec to irrigate 200 acres. How much this can be increased without a reduction in response still remains to be determined.

TABLE I

Response to irrigation expressed as the increase in tons cane per acre per inch of water applied.

	Age Months	*Rainfall ins.*	*Irrigation ins.*	*Responses t.p.a.*	*Response per inch of irrigation*
Experiment Station Chaka's Kraal for Plant Cane and 4 ratoon	69	241	60	100	1.6
*Illovo Sugar Estates. Plant cane crop	23	80	21	19	0.90
	—	—	31	21	0.70
Tongaat Experiment I. Plant cane crop	19	59.5	14	18	1.3
	—	—	20	15	0.75
1st ratoon crop	13	46	8	14	1.8
	—	—	14	13	1.0
*Tongaat Experiment II Plant cane crop	19	59.5	26	22	0.8
	—	—	21	15	0.7
	—	—	20	13	0.7
1st ratoon crop	13	46	16	14	0.8
	—	—	14	13	0.9
	—	—	14	13	0.9
Tongaat Experiment III 1st ratoon crop	13	46	4	3	0.75
	—	—	8	7	0.9
	—	—	14	8	0.6

* Considered the most reliable experiments.

With this in mind the results of these experiments have been tabulated in Table I and the responses expressed as the increase in tons cane per acre over control (no irrigation) per inch of water applied. The results are published in this form solely due to the degree of consistency they show. The more reliable results have been marked and a conservative mean taken as 0.8 tons cane per acre per inch of water applied.

Effect of Irrigation on Sucrose per cent Cane

Experiments at Tongaat have shown that irrigation does not necessarily mean a reduction in sucrose per cent cane if an attempt is made to dry off the cane prior to harvest. If controlled drying off is practised it would appear that irrigation on shallow soils stands a very good chance of improving the sucrose. The results are expressed in the table below.

TABLE II

Effect of Irrigation on Sucrose per cent Cane

	Experiment I Pl.	*Experiment I* 1 Ratoon	*Experiment II* Pl.	*Experiment II* 1 Ratoon	*Experiment III* Pl.	*Experiment III* 1 Ratoon	*Average*
Control	16.40	14.7	15.46	14.42	—	14.7	15.14
Irrigated... ...	16.50	15.4	16.03	15.60	—	15.4	15.79

N.B.—in the case of the 1st ratoon crops the increase in sucrose due to irrigation is statistically significant.

In their above form the results cannot be treated quantitatively, as irrigated refers to the mean of several different irrigation treatments. Qualitatively, however, they illustrate the point which is being made. The explanation for the increase in sucrose per cent is probably that the cane is kept in good condition during drought when it is irrigated and the green leaves are therefore able to manufacture sucrose more efficiently.

Row Spacing Trial under Irrigation

With the introduction of irrigation one of the first questions to be asked is, does one close up or open out the cane row? The same question has been asked under dry land conditions and experiments carried out indicate that varying row widths and spacing within the row did not significantly affect the yield. The explanation given by Pearson[1] was that the yield was primarily limited by moisture and therefore plant population was not so important. In the same paper Pearson shows results which indicate under irrigation continuous planting in 4 ft. 6 in. lines yielded better than when the setts were spaced.

An irrigated experiment at Tongaat appears to show that by decreasing the row widths yields of cane per acre can be increased. The experiment consisted of two replications of a factorial 4 spacings x 3 levels of nitrogen x 2 levels of potash. The levels of nitrogen were 100, 200 and 300 lbs. N. per acre and potash 120 and 240 lbs. K.20 per acre. The results obtained so far have been tabulated below.

TABLE III

Results from Spacing Trial

Row Spacing	*Plant Cane* Cane Crop = 17 mths. Rain = 69.1" App. Irrigation = 8"	*First Ratoon* Crop = 17 months Rain = 42.5" App. Irrigation = 17"
3 feet 0 inches	67.2 t.p.a.	49.3 t.p.a.
3 feet 9 inches	64.2 t.p.a.	47.2 t.p.a.
4 feet 6 inches	58.9 t.p.a.	44.8 t.p.a.
5 feet 3 inches	53.7 t.p.a.	45.0 t.p.a.

No valid reason can be given for the lower response to closer planting in the 1st ratoon crop, unless the greater rainfall the plant cane crop received was not completely compensated for by the irrigation. Three other points are worthy of mention. Firstly, at three months the first ratoon crop spaced 3 ft. 0 in. was showing signs of moisture stress, while the other cane appeared to have adequate moisture. Secondly, the reduced weed control problem at 3 ft. 0 in. spacing compared with 5 ft. 3 in. due to the rapid closing in of the cane and consequent smother effect. Thirdly, there has been no apparent interaction between the heavier application of fertiliser and the closer spacings.

Response to Nitrogen under Irrigation

In both the row spacing trial and Irrigation experiments II and III three levels of nitrogen were used. In neither case has an economic response been observed to a level of nitrogen greater than 200 lbs./acre and this only in the first ratoon crop. The results have been tabulated below.

TABLE IV

Response to nitrogen in Irrigation Experiments.

Levels of Nitrogen in lbs. N/acre.

	100	200	300	400	500
Irrigation II					
Plant t.p.a.	46.3	46.0	50.2	—	—
1st Ratoon t.p.a. ...	35.4	40.0	41.0	—	—
Irrigation III					
1st Ratoon t.p.a. ...	40.1	—	45.1	—	49.0
Row spacing trial					
Plant t.p.a.	60.2	61.5	61.3	—	—
1st Ratoon t.p.a. ...	42.3	50.0	47.5	—	—

On the basis of this information on the soils on which these experiments were carried out 100 lbs. N per acre appears to be adequate for the plant cane crop and something in the region of 200 lbs./acre for the 1st ratoon crop. These indications are followed in the fertiliser policy applied at Tongaat.

Rate of Precipitation by Overhead Irrigation

The rate at which irrigation water should be applied has been given much thought at Tongaat during recent months. By far the most popular sprays used on sugar cane are large ones which give a precipitation rate of approximately 0—1 in. per hour and these have been used in the Tongaat irrigation schemes at present in operation. Two disadvantages have been observed. Firstly, on hillsides, which consist chiefly of middle ecca shales and, to a lesser extent, lower ecca shales, a considerable quantity of water has been running off the surface. It has not been possible to give a percentage figure to this run-off but it is appreciable even in the presence of trash. Secondly, extensive puddling of the surface soil takes place under large rainers and in certain areas it has been felt that resulting soil compaction has undoubtedly retarded cane growth, tending to undo the benefit which should be possible through the introduction of irrigation. A more abstract disadvantage of large rainers has been stated in California, in that a plant can suffer physical damage which will retard growth through the impact of water and that this is a factor with large rainers. This is actually not as far fetched as it may seem, for the effect of wind in retarding the growth of plants has been demonstrated in the presence of adequate moisture at the National Vegetable Research Institute in England.

On the basis of experience in California, admittedly not with sugar cane, Gray[2] of National Rain Bird Sales and Engineering Corporation, states that the infiltration rates which should not be exceeded are:

Sandy soil	...	0.3 per hour
Loams ...	...	0.2 in. per hour
Clayey soils	...	0.15 in. per hour

It is worth recalling that a rain storm which deposits 1 in. in one hour is very heavy and definitely leads to considerable run-off and washing. The same precipitation from a rainer is not deposited continuously but in 12-15 bursts. How, therefore, can the soil on a hillside possibly absorb these bursts which are equivalent to tens, or even hundreds of inches per hour? Trash helps to stem the impact but once the trash is saturated the quantity of water involved is the same.

In the infiltration process the size of the water drops is as important as the rate of application. Again, at the National Vegetable Research Institute[2], lettuce plants have been successfully boosted by irrigation applied as a mist at the rate of 4 in. per hour when applications from conventional rainers of 1 in. per hour have been too heavy and retarded growth. A similar thing has been demonstrated at Tongaat in a crude way. Small sprinklers which produce small drops in the spray have been spaced close together to give a precipitation rate equivalent to a larger rainer throwing much lrager drops of water. At the end of the test which was carried out on shale soil, the better infiltration from the smaller rainers was obvious.

Recently rainers have been tested over the following ranges:

1. Large rainers supplying 260 g.p.m. at 75 p.s.i. spaced 180′ x 160′, precipitating 1″ per hour.
2. Large rainers supplying 200 g.p.m. at 75 p.s.i. spaced 160′ x 160′, precipitating 0.75″ per hour.
3. Medium rainers supplying 30 g.p.m. at 50-60 p.s.i. spaced 80′ x 100′ precipitating 0.4″ per hour.
4. Small rainers supplying 6 g.p.m. at 40 p.s.i. spaced 40′ x 60′ precipitating 0.2″ per hour.

The following advantages have been observed with the small rainers:

1. Puddling and run-off is reduced to nothing. In addition, the jet of water which occurs on opening and closing large rainers is avoided.
2. Less power is required for irrigation due to the lower operating pressure required for small rainers which work satisfactorily from 30-40 p.s.i. (see comparative horse power requirement at end of paper.) This is very important where the cost of power is a major factor in the development of irrigation.
3. Water distribution is improved under windy conditions as 100 per cent overlap is allowed for in the spacing, i.e. one rainer throws at least to its neighbour. This cannot be done with large rainers where 20 per cent is normal.
4. Easier control is possible over where the rainers are working. Fewer moves are involved per day as the rainers stay in one position from 4-6 hours.
5. Small rainers need not be any more expensive than large ones in labour. If capital is available to buy sufficient portable piping and rainers, operating labour can be substantially reduced. The ultimate conclusion of this is the solid set systems used in America where labour is very expensive. The whole area to be irrigated is covered with permanent pipes so that only rainers have to be set up, even this is avoided in some cases, and irrigation becomes a matter of turning taps on and off.
6. Finally, an important point which must be mentioned although it is not an advantage of small rainers over large rainers, is that very few stoppages have taken place due to blockage or breakdown during the six months the small rainers have been under test at Tongaat.

The disadvantage of the small rainers is that they require large amounts of portable piping to distribute the amount of water which can be sprayed by one large rainer and this is expensive. A considerable saving can be effected by using pipes of decreasing diameter as the flow decreases.

In conclusion it is interesting to compare capital cost of two 100 acre schemes, one using large and the other small rainers, when the water consumed is 240 g.p.m. and the portable lines are 800′ long. If it is presumed that the scheme is close to the water source and that there is a nominal lift of only 20′, then the breakdown of costs is as follows:

Large Rainer Scheme	*Cost*	*Cost*	*Small Rainer Scheme*
	£	£	
Pump, motor and drive to pump 240 g.p.m. and give a nozzle pressure 80 p.s.i. ...	740	540	Pump, motor and drive to pump 240 g.p.m. and give a nozzle pressure of 40 p.s.i.
3,000 main of asbestos cement 5" class C	1130	1040	3,000 main of asbestos cement 5" class B.
Risers and hydrants	250	250	Risers and hydrants.
Two rainers taking 240 g.p.m. and standpipes, precipitating 0.8" per hour spaced 180'×160'	110	180	Sixty rainers taking 6 g.p.m. and standpipes, precipitating 0.17" per hour spaced 60'×40'
Aluminium portable pipes, 1,000 of 5" plus bends ...	580	925	Aluminium portable pipes—three lines of 780' each using 520' of 4" and 260' of 3" plus header pipes and bends.
Total	£2,810	£2,935	**Total**

Labour to construct the scheme and erect a pump house will be extra, but the same in each case.

The comparative capital installation costs therefore differ only very slightly. It may be possible to reduce the cost of the portable pipes for small rainers by using galvanised or even plastic pipes in place of aluminium. This is being investigated.

In conclusion it must be emphasised that small rainers and slower precipitation rates are still in the experimental stage at Tongaat. In the near future, 500 acres of land at present under large rainers will be converted to small ones. The soil in this area is a heavy clay and slower infiltration should be of benefit. An experiment will be incorporated in this change-over and two adjacent areas will be observed, one irrigated by small rainers and the other by a large rainer. This is not an ideal test but over a period of time should provide some information.

REFERENCES

[1] C. H. O. Pearson, Proceeding of the S.A. Sugar Technologists' Assn., 32, 1958.

[2] A. S. Gray, The Value of slow application of water by sprinkling—National Rain Bird Sales and Eng. Corpn. pub.

[3] E. J. Winter, Irrigation Report (1954), National Veg. Res. Station, Wellesbourne, U.K.

The Chairman, Mr. Du Toit, thought it most appropriate to have two papers on overhead irrigation, particularly following the two seasons of drought we had experienced. The two papers were supplementary. He thought that they would be read with great interest in every sugar country where irrigation was necessary. The rainfall in the sugar growing areas of South Africa was one of the lowest and it was also true that water was not very plentiful for irrigation purposes. No doubt, due to this, overhead irrigation had been more developed in this country than in other parts of the world. Dr. Cleasby, referring to the effect of irrigation on sucrose, stated correctly that provided there was a reasonable drying-off period one might expect an increase in sucrose content. This was not altogether surprising because irrigation kept the leaves green when solar radiation was high, whereas without irrigation in drought, the leaves could not work so efficiently.

Mr. Thompson's results showed a most outstanding increase in sucrose content, through irrigation. Mr. Thompson explained this by saying that the irrigated plots bearing heavily suffered a greater drying out due to the experiment being burnt, and that this might not always obtain in practice. While these results could not be guaranteed in field practice, it was likely that some increase in sucrose content would be obtained. The figures shown by Mr. Thompson were perhaps accentuated by the severe heat of the accidental fire. An interesting point which he could not explain was that Mr. Thompson had indicated a much better response to potash under irrigation than under dry land conditions. Naturally with the heavier yields from irrigation one would obtain a heavy response to potash, but potash has been said to be a drought insurance.

Mr. Dymond said that with regard to the spacing experiments the fertilizer was quoted as being put on at a rate of so much per acre. Would it not be better to express this application as rate per line?

Dr. Cleasby said that this could be done but the experiments had compared different levels of nitrogen up to quite high applications and did not give any significant interaction with closer spacing.

Mr. Pearson said that in 1950 he had made enquiries as to the increases which could be attributed to irrigation and had found little more than good guesses. The papers indicated the intensive study of irrigation in the cane belt that had taken place in the last ten years. Due to queries by people who had used irrigation he had installed irrigation plants at the Experiment Station farm at Chaka's Kraal in order to find just how much gain could be attributed to irrigation. The figures so obtained were perhaps not very reliable. In the Experiment Station experiment they had endeavoured to cut a crop of about 50 tons per acre and he wondered if this might have led to the high yield per inch of water shown in Dr. Cleasby's paper. At Chaka's Kraal in the early stages irrigation was applied only during the winter period and this might have had a greater effect on the amount of water used per ton of cane. From information gained here and overseas it would appear that a better control of irrigation should have been used at Chaka's Kraal. He was pleased to see the trend away from the big sprinkler. Tests which he had carried out between big and small sprinklers were now confirmed by the tests at Tongaat. He had been using one set of galvanised pipes for just on nine years, and asked if rumours could be confirmed that aluminium pipes had been giving a certain amount of trouble over recent years.

Dr. Cleasby said one important point remarked upon by Mr. Pearson was the frequency of cutting of cane. He felt that one had to be cautious, for if the annual rate of growth was linear and one got 30 tons in 12 months and 60 tons in two years, then cutting twice in two years incurred additional expenses such as fertilizing and weeding, and would therefore be less economical. With regard to aluminium and galvanised pipes, when large rainers were used portable pipes of 4 and 5 inches diameter were required. Aluminium had to be used as galvanised piping was too heavy. With small rainers however, one could use 3 and 2 inch diameter pipes and therefore galvanised iron was possible. One big disadvantage of aluminium pipes was that once they were broken they were very often a write-off. Some plastic materials and fibre glass had been tried to repair them, as yet without real success, and if one tried welding, the join only lasted for a short while, the pipe soon breaking again near the join.

Mr. Thompson said that his criterion with regard to age of cutting of cane was that cane before being cut should be preceded by a summer period of good growth. If one did not have a good cover by the 15th January one would be advised to leave the crop until the next year.

He said with one year old cane on irrigated flatlands he got 40 tons per acre with a reasonably high sucrose due to an adequate drying-off period. Cutting at a year old they spent more money on fertilizer, but if they ran the crop for two years they reaped about 63 tons per acre, as compared with a 40 ton per acre crop for 12 months. He said that at Illovo they tended to cut cane at two years old on hillsides and one year old on the flats.

Dr. Brett asked whether any experiments were carried out, as in Hawaii, to control flowering by withholding irrigation at certain times of the year.

Mr. Thompson said he was not encouraged to try this after discussing the matter with Hawaiian technologists because here we would have to cut off the water in February, when the cane needed it most, and when fairly frequent rain could be expected anyway.

Dr. McMartin said that on the question of yield of cane per inch of water, he had averaged out pot tests on the transpiration ratio and had got a figure of 1.2″ of water per ton of cane. This figure however should be treated with caution because yield is not directly proportional to the amount of water used. As there was a different water requirement for each tonnage, he did not know if such figures meant very much. He also was not happy about the use the wilting point was put, to determine the water requirements for cane. There was not one point only at which the cane was affected by lack of water. There was one point at which cane would wilt but quite a lot of cane growth would be lost before it actually showed wilting. While this might not be so important in areas such as those discussed, where supplemental irrigation only was practised, it was of vital importance in certain areas which were something like 100 per cent dependent on irrigation.

Mr. Thompson said that the wilting point data was obtained by experiments on young sunflower plants. In practice, the difference between wilting point and the slowing up of cane growth was not so important. Using an average figure of 2.7″ for available water from one foot of soil might not satisfy Dr. McMartin's requirements but in practical working one had to use some definite figure.

Dr. Cleasby agreed that the figures shown by himself and Mr. Thompson were not accurate, but it was important to have a system to work to and later, with further information, one might be able to use more correct figures. He thought Mr. Thompson was justified in taking 2.7″ as available moisture. If one changed from a heavy soil to a sandy soil the plant would adjust itself by spreading its roots much further in the sandy soil and so obtain the necessary amount of water. He thought that for response per inch or irrigation, the figure .8, while rough, would be of use to people contemplating irrigation as an indication to what return they might gain. It implied that scientific irrigation was practised and control based on an evaporation approach as outlined by Mr. Thompson in his paper. This would require a water duty of the order of one cusec to 200-250 acres.

Dr. McMartin asked if the figures of 1′ for root development and 4.7″ for field capacity were correct. Could not 4.7″ be too high?

Dr. Cleasby replied that 4.7″ was field capacity and 2.5″ was the available water. He said it was most amazing how this actually worked in practice. He said laboratory tests indicated that when cane showed signs of drought, the laboratory records showed the moisture deficiency, based on evaporation, to be of the order of 2.5 to 3.0 inches.

Mr. Tedder asked what could be considered an economical tonnage to cut at 12 months.

Mr. Thompson said he would rather cut two 40 ton crops per two years than have to irrigate through winter and wait two years to get a 63 ton crop. The financial yield, of course, depended also upon distance from the mill.

Mr. Pearson asked where a person was compelled to cut irrigated cane, say in June or in May, whether Mr. Thompson had got any experience of whether or not there is an increase in growth due to water application for the young cane in the winter period.

Mr. Thompson in replying said that they had much experience in the effects of irrigation during winter. This was judged by crop logging results and particularly the sheath moisture tests. Additional irrigation was not found to prevent desiccation of the plants during winter when sheath moisture levels invariably fell below 75 per cent. In fact, soil temperatures seemed to be a limiting factor during winter. The crop log growth measurements shewed no increase during winter.

Mr. Pearson said it would seem that while temperatures were low irrigation would be unprofitable to apply, and that there was a critical point where one should take advantage of this temperature rise.

Mr. Thompson said he considered one should irrigate during winter, but if the amount of water put on was excessive, the effect could be harmful due to an unnecessary lowering of the soil temperature. It was obvious one had to relate these two factors to find out just how much water it was profitable to apply.

Mr. Du Toit (the Chairman) referred to the experience of a Hawaiian technologist who found that he could not quite make out when he got to Iran and started irrigating, that there was really very little response or irrigation. The air temperature was high enough, but he just could not get the cane to grow. Then he found that the water he had used came from high peaks covered in snow and the water temperature was so low that it depressed the soil temperature and therefore he got very poor growth.

Dr. Cleasby said that one should apply irrigation in the winter months. Evaporation figures were very low in June, July and August, but one should still irrigate at a rate determined by the evaporation.

Mr. M. J. Stewart said that regarding fertilizer application, he noticed that the cane yields were 40-45 tons per acre. The ratio between N-P-K was 1:1:2 and if he was right in assuming 40-45 tons per acre then a ton of cane took up to 2.0 lbs. of nitrogen and phosphate. Could one therefore estimate that the potential multiplied by this fertilizer ratio? There was not much response because they started at a fairly high level. In the case of potash it was 4.0 lbs. of K_2O per ton of cane. He asked if that being so, can we just multiply our respective crop by 4.0 lbs. and see how much potash is necessary?

Mr. Thompson said he did not think this could be done because it depended upon the actual soil fertility as shown by soil analyses or plant analyses. The actual whole cane analyses had shown a much higher K_2O removal by the crop than was indicated in the literature, where 150 lbs. K_2O per acre for a 40 ton cane crop was a figure he remembered. He would certainly be hesitant about fertilizer requirements calculated as Mr. Stewart suggested.

Mr. M. J. Stewart said that results of soil analyses should be reduced to a standard but applications could be modified according to actual requirements after analysis and experiments had indicated these.

Mr. Main asked if Mr. Thompson had established a relationship between the application of overhead irrigation and the absorption of water through the leaves of the plant. During the last drought he was amazed to see very heavy dew on leaves that were drying out. While he had been in the past convinced that a certain amount of absorption did take place, he now could find no evidence of this at all. He thought the relative merits of overhead and furrow methods should be further investigated.

Dr. Cleasby said that the terrain and the availability of water really determined which system should be used. As far as any evidence of water being taken up by the leaves was concerned, he did not know the answer and thought that it would be very difficult to investigate this point.

Dr. McMartin said that radio-active tracer studies have shown that both water and minerals can be taken up by the plant through the leaves and transported to the point where they are needed.

Mr. Main said that it might be that low temperature might have been a factor in moisture absorption. He thought further experiments might indicate whether there was any positive absorption through the leaves. He said that in the Chaka's Kraal experiment a gain of about 16 tons cane per acre was achieved by overhead as against furrow irrigation. There, humidity was determined outside the cane and below the canopy. This showed that the humidity outside was about 77 and under the canopy about 99 per cent and this was important from the point of view of soil temperatures.

Mr. Wilson noted from Dr. Cleasby's paper that a statement was made that irrigation was mostly used on soil that was subject to drought, such as shallow shales. He thought that prospects for irrigation were very considerable in this industry, but that it could be used more effectively and efficiently on the deeper soils for intensive production rather than on the shallow soils for drought insurance.

Mr. MacIver asked which was the best time to irrigate—at night time or during the day.

Dr. Cleasby said that one should, if possible, irrigate day and night considering the capital expenditure involved, but if sufficient money was available it would be better to irrigate during the day as control of irrigation was very difficult at night.