IRRIGATION CONTROL AND EXPERIMENTATION AT ILLOVO

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Introduction

Evapotranspiration or the consumptive use of water by a sugarcane crop varies both with climate and the stage of development of the crop. Summer usage is higher than that in winter and the loss of moisture from the soil immediately after planting is limited to evaporation, whilst the loss from a full cover of green leaves is almost entirely due to transpiration. In occasional climatic cycles on the Natal South Coast the total rainfall may possibly exceed the total moisture requirements of the crop, but the maldistribution of the natural precipitation invariably precludes maximum crop production without considerable irrigation. The control of overhead spray irrigation under these variable climatic conditions constitutes a problem which has received attention over the past five years at Illovo, where the soils range within fields from Recent Sands to heavy Lower Ecca Shales, and in depth from two or three inches to several feet.

Irrigation Control

Theory

Maximum production can only be realized when the vegetatively growing crop is subjected to no moisture stress, and this condition obtains essentially between the limits of Field Capacity and Wilting Point, being respectively the water holding capacity of the soil against gravity and the moisture content when plants wilt permanently. The purpose of irrigation, therefore, is to supplement rainfall to the extent that the soil does not dry out to Wilting Point until it is advantageous for it to do so during the deliberate "ripening-off" period at the end of the crop.

Some knowledge of the progressive soil moisture content variations is essential to intelligent irrigation control. In areas where rainfall is predictably very low and may be disregarded as a source of moisture for the crop, irrigation may proceed in regular time cycles. The frequency of the cycles may be based on experience with a particular crop, its growth rate or moisture content being related seasonally to irrigation intensity, or alternatively on such soil moisture measuring devices as Bouyoucos blocks or soil tensiometers. Where rainfall is significant in amount and distribution however, irrigation becomes supplementary, no matter how essential it may be, and regular cycles of irrigation can only be practised between falls of significant rain. After every rain sufficiently great to saturate all irrigated lands to Field Capacity, the process of soil dessication proceeds at essentially the same rate wherever there is a full cover of green transpiring leaf, and hence all such areas reach the stage of requiring further precipitation at the same time.

If a certain amount of overhead spray irrigation equipment is to serve a maximum area, it is therefore necessary that irrigation operations commence as soon as the first point to be irrigated can absorb an efficient cycle of irrigation, and any delay simply reduces the area irrigable or the length of drought insurance on the total area to be irrigated.

The control of established overhead spray irrigation under these conditions of climate thus hinges very largely on being able to predict when a cycle of irrigation may earliest begin, and when irrigation should cease because the total effect of irrigation and rainfall exceeds the current soil moisture deficit. To these ends instruments were found to serve little purpose and attention has therefore been concentrated on the consumptive use of water by the sugarcane crop.

The amounts of water transpired by a full cover of sugarcane leaf, and the small amounts of evaporation from the soil beneath are functions of the prevailing climatic conditions. Meteorological data such as atmospheric temperature and humidity, solar radiation and duration of sunshine have been integrated in various formulae by Blaney and Criddle,[1] Thornthwaite,[2] and Penman[3] to give reasonable estimates of daily consumptive use of water by a crop. However, the far simpler daily measurement of evaporation from a free water surface has been found to bear an approximate relationship which could well serve the purposes of practical irrigation control where rainfall periodically saturates the soil and thus eliminates all cumulative errors in the calculation of a soil moisture deficit.

In order to apply this method of control in practice under local conditions, certain assumptions have to be made to reduce complications without introducing very significant errors.

(*a*) It is assumed that all the moisture requirements of the crop are met from the top foot of soil only. This is not necessarily so, but shallower soils would require an uneconomically higher frequency of irrigation, and although deeper soils could take more irrigation applied less frequently the depth of soil on Illovo Sugar Estates irrigated land varies so greatly that an estimated one foot depth has been used and found to serve well enough in practice.

(*b*) It is assumed that Field Capacity in this top foot of soil constitutes 4.70 inches of water. This is an average of the available data for the soil types being irrigated, these being Lower Ecca Shales, Dwyka, Dolerite, Red Recent Sand, Grey Recent Sand and Alluvium.

(*c*) It is assumed that Wilting Point in the top foot of soil constitutes 2.00 inches of water, and this again is an average for the various soil types. The available water supply from the soil is thus assumed to be 2.70 inches.

(*d*) It is assumed that the consumptive use of water from a full cover of irrigated sugarcane leaf is 85 per cent of evaporation from a free water surface. This is the approximate value calculated from the data of Fuhriman and Smith[4] in Puerto Rico for the period of maximum use prior to ripening-off, and actually refers to evaporation from a U.S. Weather Bureau pan. Cowan and Innes[5] in Jamaica established a factor of 0.58 relating evapotranspiration from a full cover of cane and evaporation from a free water surface. (Factors for sugarcane from other sources range as high as 1.20, and in view of these considerable variations it is well that a co-operative experiment is now being conducted in Natal to determine the relationship under local conditions).

Partial cover by young cane leaves is estimated as a percentage of total cover each month, and a bare soil is assumed to lose 0.05 inches of moisture per day by evaporation.

(*e*) It is assumed that overhead spray is 75 per cent efficient, this figure having been determined by Fuhriman and Smith[4] in Puerto Rico.

(*f*) It is assumed that rainfall less than 0.30 inches per day, unless continuous with a previous or following day's fall, may be disregarded. Other investigators are inclined to regard all measured rainfall as being efficient but the ignoring of small amounts of precipitation may be an advantage in practice to ensure the adequacy of the theoretical system of control. Rainfall in excess of that required to raise the soil moisture to Field Capacity is regarded either as runoff or percolate, and not used by the crop.

Practice

The translation of the theory of consumptive use of moisture by the crop into practice is effected very simply by conducting a day to day soil moisture profit and loss account for the first points to be irrigated in each field. The only reliable initial reference point is immediately following a rainfall more than sufficient to saturate the top foot of soil, even if a wilting condition has previously obtained. Thereafter, the estimated evapotranspiration per day is deducted each day from an initial figure representing Field Capacity and as soon as the soil moisture deficit reaches a level equivalent to the amount of water applied in one efficient irrigation cycle, irrigation may commence.

Any rainfall exceeding 0.30 inches is added as profit to the soil moisture reservoir, and irrigation operations are suspended only when the combined effects of rainfall and irrigation exceed the current soil moisture deficit. Should the effect of rainfall alone subsequently raise the soil moisture level to Field Capacity, then irrigation is recommenced from the first points to be irrigated in the field, and the field as a whole is credited with an irrigation cycle only if more than half of the field had already been irrigated. If, however, the effect of rainfall alone has been insufficient to raise the soil moisture level to Field Capacity, then irrigation is recommenced on the same points at which it was suspended, and this when evapotranspiration has theoretically accounted for the amount of rainfall exceeding one efficient irrigation cycle less than Field Capacity. The field is credited with a single irrigation cycle.

A sample irrigation control sheet is shown in Appendix I.

Since rainfall is reasonably frequent during parts of the year, irrigation operations are planned only for a week in advance. In order to do this satisfactorily it is necessary to predict the approximate evapotranspiration per day for the week. At Illovo, average S.A.S.A. Experiment Station evaporation data from Mt. Edgecombe have been used in the past, the average daily evaporation for each month being multiplied by the factor 0.85 to give the estimated daily evapotranspiration. At the end of each week a correction is made for any significant difference between these data and those measured during the week in the local evaporation tank.

The data used for predicting the evapotranspiration from a full cover of cane are shown in Table I:

TABLE I

MONTH	*Average Evaporation per day—inches*	*Average Evapotranspiration per day—inches*
January	0.19	0.16
February	0.16	0.14
March	0.15	0.13
April	0.11	0.09
May	0.09	0.08
June	0.08	0.07
July	0.09	0.08
August	0.09	0.08
September	0.12	0.10
October	0.14	0.12
November	0.16	0.14
December	0.18	0.15

When the cane crop is deliberately dried off prior to harvest in order to raise the sucrose content, the soil moisture level falls to Wilting Point. The control of irrigation during this period would normally be based on sheath moisture values, these values being required to fall gradually and steadily from approximately 80 per cent to 73 per cent over the drying-off period. The only reliable drying-off period under local climatic conditions is from May to August, and it has been found by experience that irrigation can safely be suspended towards the end of May if the cane is to be harvested in the August-September period.

After harvesting a field, the estimated daily consumptive use is reduced to 0.05 inches per day, and thereafter increased monthly as the proportion of canopy increases until full green leaf cover is once again obtained.

Irrigation Experimentation

In accordance with the general policy at Illovo of instituting experiments to study problems of sugarcane agriculture under local conditions, an experiment was designed and laid down to determine the adequacy of the system of irrigation control whilst also attempting to measure the value of irrigation in terms of response to water application.

Design of Experiment

The site selected for the experiment was a very gently sloping area of Lower Ecca Shale with 8-12 inches of top soil overlying a well-weathered subsoil down to three feet. The shape of the available land, bounded on one side by a canal and on the other by a road, was surveyed and the possible disposition of the 54 plots superimposed on the plan.

It was decided that the plots should be square with a quarter-circle rainer located on each corner so that the overlap design would simulate a perfectly representative area in a field irrigated with a square system of rainer points. Low pressure rainers with $\frac{3}{16}$ inch diameter nozzles were selected. The exact plot size was 0.02278 acres, being nine rows 3 ft. 6 ins. apart and 31 ft. 6 ins. long. The rows were planted 1 ft. 9 ins. short at each end in an attempt to reduce end effect. The breaks between plots were 8ft. 6 ins. wide.

Three levels of water were included in the experiment, the first W_0, being dry land conditions relying entirely on natural precipitation. The second level, W_1, was designed to represent average irrigated field conditions, which involved irrigating so that the mid-point between Wilting Point and Field Capacity was reached half way through the application of water to the W_1 plots. The third level of water, W_2, involved the application of water to the plots as soon as the soil could theoretically absorb one efficient cycle of irrigation to raise it to Field Capacity. This level represented the equivalent of the first point to be irrigated in a field scale scheme, and was intended in effect to test the adequacy of average field practice. The estimated consumptive use of water by the crop was calculated from average evaporation data, using a factor of 0.85, and irrigation was based on soil moisture profit and loss accounts as in field practice. A sample irrigation control sheet for the experiment is shown in Appendix II.

The fertilizer levels compounded factorially with the three levels of water were:

Nitrogen = 3 levels: 100, 200 and 300 lbs. N. per acre.
Phosphate = 2 levels: 100 and 200 lbs. P_2O_5 per acre.
Potash = 3 levels: 0, 200 and 400 lbs. K_2O per acre.

There were no replications, the experiment comprising 54 plots only.

Experimental Procedure

The Field Capacity of the soil on the experimental site was determined at five different points for the top three feet of soil, each foot of depth separately by the method described by Piper.[6] The results are shown in Table II. The Wilting Points were not determined but assumed to be 2.50 inches for the top foot of soil.

TABLE II

Site No.	*Depth of soil in feet*	*Field Capacity acre—Ins.*
1	0–1	5.18
	1–2	5.61
	2–3	5.14
2	0–1	4.56
	1–2	5.24
	2–3	5.64
3	0–1	5.48
	1–2	5.68
	2–3	5.53
4	0–1	5.36
	1–2	5.80
	2–3	5.20
5	0–1	6.01
	1–2	5.93
	2–3	4.33
Average	0–1	5.32
	1–2	5.65
	2–3	5.17

The plots were planted on 6th September, 1957, with N:Co.310 seed cane. A complete lattice of drains 18-24 inches deep was subsequently dug to separate all plots. All of the phosphate and one-third of the nitrogen and potash fertilizers was placed in the furrow at the time of planting. A first top dressing of a further one third of the total nitrogen and potash applications was made on 20th January, 1958, and the final amounts were applied on 24th September, 1958.

Irrigation was carried out exclusively at night when there was no wind. This proved to be the severest problem in the conducting of the experiment, delays due to wind in one instance causing the W_1 plots to fall to Wilting Point for a short period. The rainer standpipes were initially 3 ft. 9 ins. high, and subsequently 8 ft. 9 ins. high when the cane had

TABLE III

TOTAL RAINFALL, EFFECTIVE RAINFALL, EFFECTIVE IRRIGATION AND TOTAL EFFECTIVE WATER DATA

September, 1957 to August, 1959

MONTH	*Total Rain Inches*	*Effective Rain Inches*			*Effective Irrigation Inches*		TOTAL EFFECTIVE WATER						*No. of Days W_0 Plots at W. Pt.*
							MONTH			*TO-DATE*			
		W_0	W_1	W_2	W_0	W_2	W_0	W_1	W_2	W_0	W_1	W_2	
1957													
September	1.21	0.45	0.45	0.45	—	—	0.45	0.45	0.45	0.45	0.45	0.45	—
October	3.23	0.96	0.96	0.96	—	—	0.96	0.96	0.96	1.41	1.41	1.41	—
November	4.54	2.09	2.09	2.09	—	—	2.09	2.09	2.09	3.50	3.50	3.50	—
December	4.60	1.86	1.86	1.86	—	—	1.86	1.86	1.86	5.36	5.36	5.36	—
1958													
January	6.71	5.43	5.43	4.43	—	1.00	5.43	5.43	5.43	10.79	10.79	10.79	—
February	8.06	1.96	1.96	1.96	—	1.00	1.96	1.96	2.96	12.75	12.75	13.75	—
March	5.02	3.87	2.87	1.87	1.00	2.00	3.87	3.87	3.87	16.62	16.62	17.62	—
April	9.89	2.91	2.91	1.91	—	—	2.91	2.91	1.91	19.53	19.53	19.53	—
May	0.21	—	—	—	2.00	3.00	—	2.00	3.00	19.53	21.53	22.53	9
June	0.79	0.79	0.79	0.44	1.00	2.00	0.79	1.79	2.44	20.32	23.32	24.97	20
July	0.64	0.45	0.45	0.45	2.00	2.00	0.45	2.45	2.45	20.77	25.77	27.42	26
August	0.18	—	—	—	3.00	2.00	—	3.00	2.00	20.77	28.77	29.42	31
September	2.22	2.02	1.88	1.27	1.00	2.00	2.02	2.88	3.27	22.79	31.69	32.69	11
October	4.76	3.06	3.06	2.93	—	—	3.06	3.06	2.93	25.85	34.71	35.62	16
November	5.05	3.30	3.30	2.30	—	2.00	3.30	3.30	4.30	29.15	38.01	39.92	—
December	3.77	2.72	2.54	1.47	3.00	4.00	2.72	5.54	5.47	31.87	43.55	45.39	8
1959													
January	4.73	4.40	4.40	3.34	1.00	2.00	4.40	5.40	5.34	36.27	48.95	50.73	1
February	2.72	2.48	2.43	1.68	1.00	2.00	2.48	3.43	3.68	38.75	52.38	54.41	10
March	0.90	0.61	0.61	0.61	3.00	3.00	0.61	3.61	3.61	39.36	55.99	58.02	27
April	1.05	0.77	0.77	0.69	3.00	3.00	0.77	3.77	3.69	40.13	59.76	61.71	23
May	6.61	3.96	2.37	1.53	—	—	3.96	2.37	1.53	44.09	62.13	63.24	4
June	—	—	—	—	—	—	—	—	—	44.09	62.13	63.24	5*
July	2.78	2.40	2.40	2.40	—	—	2.40	2.40	2.40	46.49	64.53	65.64	7*
August	0.14	—	—	—	—	—	—	—	—	46.49	64.53	65.64	24*
TOTAL	79.81	46.49	43.53	34.64	21.00	31.00	46.49	64.53†	65.64†				186

* Indicates deliberate drying off and therefore not included in the total number of days at Wilting Point.

† Difference between amounts of Total Effective Water on W_1 and W_2 plots due to:

(*a*) Irrigation slightly exceeding Field Capacity on occasions for W_2 plots, and

(*b*) W_1 plots being at Wilting Point for seven days in October, 1958 when wind consistently delayed irrigation.

developed in height. Four plots were irrigated simultaneously, 16 rainers thus being in operation at any one time. Each application amounted to 685 gallons per plot of 0.0228 acres. This represented a total application of 1.33 inches, or 1.00 inches of efficient water per application.

The W_2 plots were thus irrigated when the estimated soil moisture level had fallen to 4.32 inches in the top foot of soil, and the W_1 plots when the estimated level on these plots had fallen to 3.41 inches. Actual rainfall, efficient rainfall and irrigation data are shown in Table III.

The plots were deliberately dried off from the end of May 1959, preparatory to harvesting at the end of August, 1959. Flowering occurred extensively during the first winter's growth.

The experiment was burnt before harvesting on 31st August, 1959. The outside row on both sides of each plot was discarded to eliminate border effect, and because of the very pronounced end effect on the remaining seven rows per plot, 5 ft. 3 ins. of row was measured off exactly at each end, cut and discarded. The area actually harvested was therefore 0.01181 acres per plot, which areas appeared to be free of edge effects entirely.

Discussion of Results

A study of the precipitation data in Table III reveals the following:

WATER LEVEL		W_1	W_1	W_2
Total rainfall,	Inches	79.81	79.81	79.81
Total irrigation	,,	Nil	27.93	41.23
Total Water	,,	79.81	107.74	121.04
Effective rainfall	Inches	46.49	43.53	34.64
Effective irrigation	,,	Nil	21.00	31.00
Total effective water	,,	46.49	64.53	65.64
Total ineffective water	Inches	33.32	43.21	55.40
Ineffective Water per cent Total Water		42	40	46

It will be observed that the total rainfall (79.81″) for the crop cycle exceeded the total estimated crop requirements (65.64″) by a considerable margin but that the poor distribution of the natural precipitation was such that 42 per cent of it was ineffective even in the dry land plots. The necessity for irrigation under such climatic conditions is thus revealed as compensation for maldistribution of rain rather than inadequate rain. The dry land plots were theoretically at Wilting Point for 186 days prior to deliberate drying-off of the crop before harvesting, and it is the effects of these periods of inadequate available moisture which must constitute the reason for any differences in yield due to water treatments. The fact that 73 of these days occurred during the second peak season of growth, December 1958 to May 1959 shows the absolute necessity for summer irrigation. Failure to appreciate the difference between total and effective rainfall during summer could lead to a false sense of security, with irrigation being suspended when its effects are most profitable.

The mean yields in terms of tons cane per acre are shown in the following table:

There is a very highly significant increase due to the first level of water, but the increase of W_2 over W_1 is only slight.

The linear response to potash is very highly significant.

There is a highly significant W—K interaction, showing that there is a far greater response to water in the presence of K than in its absence.

There is a significant P—K interaction indicating that the higher level of P depresses the yield in the absence of K, but seems to increase it in the presence of K.

The average sucrose per cent cane data are shown on page 166.

TABLE IV

MEAN YIELDS—TONS CANE PER ACRE

Treatment	N_1	N_2	N_3	P_1	P_2	K_0	K_1	K_2	*Mean*
W_0	30.16	28.63	28.67	29.85	28.45	27.64	28.81	31.02	29.15
W_1	43.61	46.83	46.01	46.57	44.40	39.13	46.86	50.46	45.48
W_2	47.36	45.43	46.85	47.41	45.68	37.89	49.28	52.47	46.54
P_1	40.23	41.95	41.64	—	—	37.31	42.68	43.84	41.27
P_2	40.52	38.64	39.38	—	—	32.47	40.62	45.45	39.51
K_0	35.80	34.32	34.54	—	—	—	—	—	34.89
K_1	40.48	42.89	41.57	—	—	—	—	—	41.65
K_2	44.84	43.67	45.42	—	—	—	—	—	44.65
Mean	40.37	40.30	40.51	41.27	39.51	34.89	41.65	44.65	40.39

TABLE V

SUCROSE PER CENT CANE

Treatment	N_1	N_2	N_3	P_1	P_2	K_0	K_1	K_2	*Mean*
W_0	15.78	15.71	15.96	16.09	15.54	15.66	16.05	15.73	15.81
W_1	16.27	16.80	17.72	16.99	16.88	16.36	17.27	17.16	16.93
W_2	18.18	17.94	18.64	18.28	18.22	18.25	18.23	18.27	18.25
P_1	16.68	16.68	17.81	—	—	16.95	17.30	17.10	17.12
P_2	16.81	16.77	17.06	—	—	16.57	17.06	17.01	16.88
K_0	16.53	16.54	17.21	—	—	—	—	—	16.76
K_1	17.07	17.19	17.29	—	—	—	—	—	17.18
K_2	16.64	16.71	17.81	—	—	—	—	—	17.05
Mean	16.74	16.81	17.44	17.12	16.88	16.76	17.18	17.05	17.00

The average increase in sucrose per cent cane due to the application of water is:

$$1.22 \pm \begin{array}{l} 0.59 \text{ at } 5\% \text{ level.} \\ 0.79 \text{ at } 1\% \text{ level.} \end{array}$$

This is very highly significant.

The mean yields in terms of tons sucrose per acre are shown in Table VI.

TABLE VI

MEAN YIELD—TONS SUCROSE PER ACRE

Treatment	N	N_2	N_3	P	P_2	K_0	K	K_2	*Mean*
W_0	4.77	4.51	4.58	4.81	4.43	4.33	4.64	4.89	4.62
W_1	7.06	7.91	8.20	7.93	7.53	6.42	8.10	8.66	7.73
W_2	8.62	8.13	8.73	8.66	8.32	6.91	8.99	9.57	8.49
P_1	6.75	7.10	7.55	—	—	6.36	7.45	7.60	7.13
P_2	6.89	6.61	6.79	—	—	5.42	7.05	7.82	6.76
K_0	5.98	5.69	6.00	—	—	—	—	—	5.89
K_1	6.96	7.50	7.28	—	—	—	—	—	7.24
K_2	7.52	7.37	8.24	—	—	—	—	—	7.71
Mean	6.82	6.85	7.17	7.13	6.76	5.89	7.24	7.71	6.95

There are very highly significant responses to both water and potash, but in neither of these cases is the response linear.

There is a highly significant interaction between water and potash showing that either of these factors gives a greater response in the presence of the other.

The P—K interaction is significant.

The average data for fibre per cent cane for the different water treatments are shown in Table VII:

TABLE VII

Fibre per cent Cane

Treatment	*Mean*
W_0	13.91
W_1	13.75
W_2	12.93

The average decrease in per cent fibre for water levels is:

$$-0.49 \pm 0.34 \text{ at } 5\% \text{ level,}$$

which is significant.

Since there was not a significant response to increasing N or P treatments in terms of either cane or sucrose per acre, and since the K_2 level of potash gave the maximum yield at all levels of water, an evaluation of the water treatments with adequate nutrition may best be made from the following summary:

Water Level	*Tons Cane per acre*	*Sucrose per cent Cane*	*Tons Sucrose per acre*
W_0	31.02	15.73	4.89
W	50.46	17.16	8.66
W_2	52.47	18.27	9.57

Whilst it may confidently be stated that a response to water treatment independent of the level of treatments, in the order of 20 tons of cane per acre can be anticipated in a plant crop, there must be some hesitation in predicting that the highly significant increases in sucrose per cent cane due to water application in this experiment are likely to be obtained in field practice. It is almost certain that the generally high sucrose levels were due largely to the dessicating effect of the extremely hot fire which burnt the cane. The moisture contents of the cane samples have been calculated, and if the averages for water treatments are converted to a standard 70 per cent, the effects on sucrose per cent cane are as follows:

Water Level	ACTUAL			CONVERTED		
	Moist. per cent Cane	*Sucrose per cent Cane*	*W_x—W_0 Sucrose per cent Cane*	*Moist. per cent Cane*	*Sucrose per cent Cane*	*W_x—W_0 Sucrose per cent Cane*
W_0	68.73	15.81	—	70.00	15.17	—
W_1	67.67	16.93	1.12	70.00	15.71	0.54
W_2	66.98	18.25	2.44	70.00	16.58	1.41

A great proportion of the difference in sucrose per cent cane between treatments is thus shown to be due to moisture content. Since Estate harvest data do not indicate that irrigated cane has a significantly higher sucrose content than dry land cane, it is quite possible that this response to irrigation in field practice may be obtained in terms of tons cane per acre rather than sucrose per cent cane.

The increasing sucrose per cent cane at a standard moisture content is difficult to explain, and until sucrose studies have been conducted for the different treatments in both the first and second years of growth of the first ratoon stage, and it is attempted to relate the results to climatic conditions, no full interpretation of the sucrose data can be offered. It is important, nevertheless, to know how safely the experimental data may be used to study the economics of irrigation, and it is interesting to note the following harvest data for a hillside field of 46 acres which was harvested as a first ratoon, N:Co.310, both in 1954 and 1958:

Year	*Treatment*	*Yield, Tons Sucrose/Acre*
1954	Dry land	2.64
1958	Irrigated	6.30
	Difference	3.66

The increased yield due to irrigation at the W_1 level in the experiment was 3.77 tons sucrose per acre, and for purposes of an economic evaluation a response of 3.50 tons sucrose per acre over 24 months has been assumed and found to give a profit entirely warranting the expenditure for irrigation.

Regarding the experiment as a test of the adequacy of the theoretical method of irrigation control, it is unfortunate that the factor relating evaporation from a free water surface and evapotranspiration from a full cover of cane had not been studied locally prior to the institution of this experiment. If the indications that the factor in summer considerably exceeds 0.85 prove to be valid, then the higher sucrose yield at the W_2 level might be obtained even in field practice. It is extremely doubtful that such a high frequency of overhead irrigation would be economically warranted however, and it would then be necessary in practice to assume a soil depth of 18 inches or more to contain the available soil moisture if existing equipment were to serve the same area.

Conclusions

The conclusions which may be reached following the harvest of the plant stage of this experiment are:

(*a*) that 100 lbs. of nitrogen per acre is adequate for the plant stage of either irrigated or dry land cane on this type of soil.

(*b*) that 100 lbs. of P_2O_5 per acre is also adequate under both irrigated and dry land conditions.

(*c*) that highly economical responses to 400 lbs. of K_2O per acre may be obtained on irrigated land, but the small returns in relation to outlay on dry lands probably warrants no more than 200 lbs. K_2O per acre for these conditions.

(*d*) that adequate balanced nutrition is imperative if the value of irrigation is to be realized.

(*e*) that the average level of irrigation, W_1, is the most economical water treatment although higher yields of sucrose per acre may be obtained at higher levels of water.

(*f*) that the response to irrigation at the rate of 28 inches of water per two year crop on hillside land is approximately 3.5 tons sucrose per acre where the cane suffers from no other limitation.

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For discussion on this paper see page 174.

APPENDIX I

IRRIGATION CONTROL

SOIL MOISTURE LEVELS—MARCH, 1958

FIELD		A		B		C	
STAGE		FULL CANOPY		FALLOW		$\frac{3}{4}$ CANOPY	
Daily Evapotranspiration, inches		0.13		0.05		0.11	
Total Irrigation/Application		1.24		1.24		1.33	
Effective Irrigation/Application		0.93		0.93		1.00	
Date	*Rainfall*	*Inches Irrigation*	*Soil Moisture*	*Inches Irrigation*	*Soil Moisture*	*Inches Irrigation*	*Soil Moisture*
1	—	—	3.17	—	4.15	—	4.43
2	—	—	3.04	—	4.10	—	4.32
3	—	—	2.91	—	4.05	—	4.21
4	—	0.93	3.71	—	4.00	—	4.10
5	—	—	3.58	—	3.95	—	3.99
6	—	—	3.45	—	3.90	—	3.88
7	—	—	3.32	—	3.85	—	3.77
8	—	—	3.19	—	3.80	—	3.66
9	—	—	3.06	—	3.75	—	3.55
10	—	—	2.93	—	3.70	1.00	4.44
11	—	—	2.80	—	3.65	—	4.33
12	0.81	—	3.48	—	4.41	—	4.70
13	0.06	—	3.35	—	4.36	—	4.59
14	0.03	—	3.22	—	4.31	—	4.48
15	0.11	—	3.09	—	4.26	—	4.37
16	—	—	2.96	—	4.21	—	4.26
17	—	—	2.83	—	4.16	—	4.15
18	—	—	2.70	—	4.11	—	4.04
19	3.42	—	4.70	—	4.70	—	4.70
20	—	—	4.57	—	4.65	—	4.59
21	—	—	4.44	—	4.60	—	4.48
22	—	—	4.31	—	4.55	—	4.37
23	—	—	4.18	—	4.50	—	4.26
24	—	—	4.05	—	4.45	—	4.15
25	—	—	3.92	—	4.40	—	4.04
26	—	—	3.79	—	4.35	—	3.93
27	—	0.93	4.59	—	4.30	—	3.82
28	—	—	4.46	—	4.25	—	3.71
29	—	—	4.33	—	4.20	—	3.60
30	—	—	4.20	—	4.15	1.00	4.49
31	—	—	4.07	—	4.10	—	4.38

APPENDIX II

SOIL MOISTURE LEVELS—SEPTEMBER, 1958

PLOTS		W_0		W_1		W_2	
Estimated Daily Evapotranspiration		0.10″		0.10″		0.10″	
Effective Irrigation per Application		Nil		1.00″		1.00″	
Day	*Rainfall*	*Effective Irrigation*	*Soil Moisture Level*	*Effective Irrigation*	*Soil Moisture Level*	*Effective Irrigation*	*Soil Moisture Level*
1	—	—	W. Point	—	3.91	—	4.52
2	—	—	,,	—	3.81	—	4.42
3	—	—	,,	—	3.71	1.00	5.32
4	0.02*	—	,,	—	3.61	—	5.22
5	—	—	,,	—	3.51	—	5.12
6	—	—	,,	1.00	4.41	—	5.02
7	—	—	,,	—	4.31	—	4.92
8	0.68	—	3.08	—	4.89	—	5.32
9	—	—	2.98	—	4.79	—	5.22
10	0.20	—	3.08	—	4.89	—	5.32
11	0.67	—	3.65	—	5.32	—	5.32
12	—	—	3.55	—	5.22	—	5.22
13	—	—	3.45	—	5.12	—	5.12
14	—	—	3.35	—	5.02	—	5.02
15	0.12*	—	3.25	—	4.92	—	4.92
16	—	—	3.15	—	4.82	—	4.82
17	0.02*	—	3.05	—	4.72	—	4.72
18	—	—	2.95	—	4.62	—	4.62
19	—	—	2.85	—	4.52	—	4.52
20	0.04*	—	2.75	—	4.42	—	4.42
21	—	—	2.65	—	4.32	—	4.32
22	—	—	2.55	—	4.22	1.00	5.22
23	—	—	W. Point	—	4.12	—	5.12
24	—	—	,,	—	4.02	—	5.02
25	—	—	,,	—	3.92	—	4.92
26	—	—	,,	—	3.82	—	4.82
27	—	—	,,	—	3.72	—	4.72
28	0.47	—	2.87	—	4.09	—	5.09
29	—	—	2.77	—	3.99	—	4.99
30	—	—	2.67	—	3.89	—	4.89
TOTAL	2.22	Nil		1.00		2.00	

* Rainfall less than 0.30 inches in a continuous fall is disregarded.