THE DEPENDENCY OF THE YIELDS OF CANE ON THE AVAILABLE MOISTURE DURING THE YEAR

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Any field worker, when studying the yields of cane from the coastal belt of Natal, will notice the fluctuations in yield which occur. Yields of plant cane and 1st ratoon can easily be equalled by the third ratoon crop. It has often occurred when examining old field experimental data that attention has suddenly been focussed on a ratooning crop giving higher yields and higher increases due to fertiliser. When an examination of the causes of these sudden increases is studied, in the majority of cases a good annual rainfall or two good rainfalls coinciding seems to be the cause. 1942 and 1943 are years which again and again occur in the examination of field data, and the published mean rainfalls of 44 centres for these two years were 49.40 and 53.31 inches respectively.

The annual rainfall is however a very misleading factor. Take 1953, a year which is still vividly in the memory of all planters. The annual rainfall for the Experiment Station was 44.5 inches, apparently a satisfactory total, especially when compared with the three previous years of 1950, 25.09 inches, 1951, 34.37 inches and 1952, 33.81 inches. It was, however, during 1953 that a very severe winter drought was experienced lasting 4½ months, when only 0.85 inches of rain were recorded.

The apparently satisfactory total of 44.5 inches had been made up of 14.77 inches in January, 7.70 inches in February, 1.64 inches in March, 1 inch at the beginning of April, then recordings of under 0.25 inches for May, June and July, 2.57 inches in August, 3.33 inches in September and 12.73 inches during October, November and December.

In fact it is the opinion of the writer that 1953 might have been disastrous to the cane if the trash blanket, which is now extensively in operation, had not created a sufficient mulch to keep the soil moisture from evaporating from the surface and thus extended the effective period of the early rains. Despite this mulch, the cane in many places suffered. Crops, where heavy dressings of nitrogen had been applied to shallow, well-drained soils, showed dead sticks and stools. A considerable quantity of cane, especially the variety Co. 331, showed pithiness in the stick and the ratooning on steep hillsides has in many places come away very badly.

Thus it is not only the amount of rain that falls during a period, but also the distribution of that rainfall, that has a marked effect on the crop.

It has been noticed that where overhead irrigation is applied in small quantities, ¾ to 1 inch per application, and where the interval between the irrigation periods has been reduced to once per week, when rain has not fallen, a uniform internode of some 4 inches in length is maintained throughout the winter period.

Such growth cannot be maintained except with adequate fertiliser, and the presence of the moisture in the soil allows such fertilisers to become available to the crop. Now in the cane belt of South Africa nature does not favour the artificial application of water. The rivers mainly flow in deeply eroded valleys well below the level of the cane fields. The sources of underground water are limited to supply bore-holes sufficient for domestic requirements, and only in one known case in the Groutville area could borehole water be raised in sufficient quantities for irrigation. Natural lakes are limited to one area, between Empangeni and the sea. It therefore means that by the time water is delivered to the cane fields it is of considerable cost and must be used to the best advantage to ensure an economic return.

If, therefore, this valuable commodity is to be put to the best uses, let us consider all factors governing its use by the plant.

The water, to benefit the plant, must come in contact with the plant tissues, whether they be root or leaf. In the first instance let us consider the more normal method of entry to the plant through the root.

In this instance the medium in which the roots exist, the soil, must be the conveyor of water, and here we have a variable medium, which according to its structure and composition, is capable of holding varying quantities of water. Clays may hold 33% of their own volume of moisture, whilst sands may only hold 10%. Thus when dealing with the application of water to a clay soil, providing penetration can be effected, a larger quantity of water, calculated to last a longer period before the next application, can be expected, than when the soil is sandy.

Between these two extremes lie every shade of variation, and therefore the soil at Chaka's Kraal Experiment Farm was considered with a view to irrigation.

This soil is a shale some 24 inches in depth, having a maximum water holding capacity of 17-18% of its own volume. Thus an acre of this soil would to its full depth of 24″ have a volume of some 87,120 cubic feet. If its water holding capacity were 18%, the total volume of water that could be held by this soil would be 978,531.84 gallons or 4.32 acre inches of water.

It is unlikely that such a soil under irrigated conditions would ever drop below 10% moisture. In other words its water holding would not drop below 2.4 inches. To return it to saturation it would only need 1.92 inches of water.

It was for this reason that at first it was decided to apply the irrigation at the rate of 1 inch per week, and compare it with the more normal practice of applying the water to the furrow irrigated plots at a rate of three inches every three weeks.

It was realised that to irrigate too small an area might be misleading as the seepage and spread of water laterally in the soil would affect the surrounding cane.

Three plots of $\frac{3}{4}$ acres were marked out and the treatments were to be:

Plot 1. Left to climatic conditions (hereafter referred to as dry land).

Plot 2. When rain did not fall, spray irrigation to be applied at 1 inch per week, (spray plot).

Plot 3. When three applications of water had been applied to plot 2, the same volume should be applied to plot 3 by furrow application.

As a result of previous trials it had been decided to adopt the 1″ size spray with two $\frac{7}{32}$ nozzles. These gave a uniform coverage radius to allow for a set up of 40 ft. between sprays and 60 ft. between lines.

Two lines were run down the plots and the area was covered by 12 sprays whose set up position in the field was marked by iron standards.

This gave an area contained between the sprays of 0.25 acres, which would be comparable with a normal commercial field receiving all-over spray irrigation, and would not be effected by any border effect as there would be growing cane surrounding the whole area to be cut and weighed.

Similar areas were marked out in the dry land and the furrow irrigated plots.

To ensure the equal application of water to both furrow and spray plots, all water was taken from a square brick and concrete tank and the exact measurements of the water used was recorded.

In 1952 spraying started in February, and 23 sprayings were applied between February and the end of July. Some 256,632 gallons of water passed through the tank, giving a rate of application of 0.49 inches per application. During the same period, the furrow irrigated plots received 233,118 gallons of water, the applications varying considerably as difficulty was at first experienced in effecting the required rate of application. To ensure even distribution, it was found necessary to dam each inter-row, and allow the water to fill each dam and then percolate into the soil at a slower speed than would be allowed by the open run down the furrow. The field had been planted to N:Co.310 with 600 lbs. of superphosphate applied in the furrow. 250 lbs. of sulphate of ammonia was applied at the normal time of top dressing when the cane was established.

As soon as irrigation started it was apparent that the spray irrigated plots were taking the lead, and by the end of July it was decided that both irrigated plots could be cut before the mills closed.

Cutting was done in December, 1952. The dry land plot then had barely 20 tons of cane per acre standing, and it was considered advisable to leave this.

So as to give all irrigation treatments an even chance the whole area was top dressed with 400 lbs. sulphate of ammonia in January 1953. The dry land cane was dressed at 12 months old with a similar amount.

Spray irrigation started again in March and continued until October, during which time 19 applications of 1.46 inches per application were carried out.

The furrow irrigated plots, now that trash was lying over the ground, received somewhat different treatment from the previous year, the water being allowed to flow through the trash in the inter-rows. This method did not cause sufficient water to be applied to the plots, so more frequent applications were made. 21 applications in all were carried out at a rate of .99 inches per application. The table below gives the yields, amounts of water added, rainfall, and the tons sucrose and cane per acre and per inch of total water.

Treatment	Total area in acres	Area cut in acres	Inches of irrigation water	Inches of rain	Total water	Tons cane per acre	Sucrose % cane	Tons sucrose per acre	Tons cane per 1″ water	Tons sucrose per 1″ water
Furrow 1952	.822	.372	12.52	34.68	47.20	36.11	15.86	5.73	0.765	.12
Furrow 1953	.822	.372	20.98	46.49	67.47	38.93	14.53	5.65	0.577	.08
TOTALS			33.50	81.17	114.67	75.04		11.38	0.654	.09
Spray 1952...	.97	.255	20.26	34.68	54.94	50.13	15.41	7.72	0.912	.14
Spray 1953...	.97	.255	27.80	46.49	74.29	58.39	13.0	7.59	0.786	.10
TOTALS			48.06	81.17	129.23	108.52		15.31	0.839	.12
DryLand 1953	1.08	.372		81.17	81.17	56.41	13.3	7.50	0.695	.09

From the above figures, if the tons cane per inch of water figure for each treatment is taken and multiplied by 81.17, the rainfall of the period, it is seen that dryland would produce 56.41 tons cane per acre, furrow irrigation would produce 53.08 tons cane per acre, 94.1% of the dry land crop, and spray irrigation, would produce 68.1 tons cane per acre or 120.72% of the dry land crop. On this basis it would appear that although extra water, applied by the furrow methods, will give an increased yield, the effectiveness of the watering is inferior to that applied spasmodically by natural rainfall. The spray irrigation on the other hand appears to produce an effect in both total yield of crop and in tons cane per inch of water, which is superior to rainfall and furrow irrigation.

The main differences in application of irrigated water are:

(1) The leaf is not wetted by the water when furrow irrigation is practised but it is in the spray irrigation. Work in America and Israel has been directed on the subject of absorption of moisture through the leaf tissues and attempts are being made in arid areas to utilise the dew as a source of moisture to allow growth.

(2) The water applied to the furrow irrigated plots is not so saturated with oxygen, as it usually has been contained in volume for some period prior to application, whereas the spray irrigation water is passed in fine droplets through the air prior to application, when oxygen is absorbed.

In Formosa a careful study has been made of this factor and it is felt that the oxygen so absorbed is carried down into the soil where it is released and creates beneficial conditions for growth.

Either or both of these factors may be the cause of this superiority for the spray irrigation.

As water on the cane belt is either unsuitably situated, in deeply eroded valleys necessitating costly initial lifting, or in short supply, it would appear that the more efficient use of this water by spray irrigation should, wherever possible, be put into practice. The extra capital and cost of building up pressure to apply the water by spray would seem to be justified by the extra effectiveness of the water thus applied.

The practical adoption of such a system as the spray irrigation of cane, should receive greater attention, for where irrigation is being used for experimental purposes, such as attempting to find the optimum rates of application and intervals between applications, it is difficult to assess the economic commercial aspect of the system.

It has been found possible even under experimental conditions where pipes have to be transferred over considerably greater distances from trial to trial, rather than from one set up point to the next, to handle up to half a cusec with 3 boys. Commercially the writer has seen upwards of a cusec being handled by the same number of boys, all pipes and sprinklers being moved by this gang. This compares very favourably with the labour force required by ground application, where a cusec usually requires four boys. The distribution of water would appear, once the system of pipe moving had been standardise, to be more uniform by the overhead method than by the ground irrigation, and the overhead system can cope with level ground and porous ground where application would be difficult or impossible.

It is therefore perhaps only a matter of time, to allow the overhead system to be evolved to the full in the cane fields, before this system becomes universally adopted in South Africa, where the necessity of the conservation of water and its application in the most efficient manner is so essential.

Mr. Palairet thought that though uneconomical on dry land, it would probably pay under irrigation to move the new trash and rotovate in the old. He considered that this would increase the water-holding capacity of the soil and he hoped that this idea would be tested by experiment.

Mr. Pearson pointed out that after thirteen months of spray irrigation there was no trash left. Under furrow irrigation, however, there was a heavy layer of un-rotted trash on the surface. Under spray irrigation therefore the trash was being rotted down and being washed into the surface soil.

Mr. Main said that with spray irrigation trashing was no problem but it could lead to trouble with furrow irrigation. He thought that one of the biggest advantages of leaving trash on the ground was that the roots were undisturbed. However, it might be advantageous to incorporate the trash when furrow irrigation was used.

Mr. Pearson said that under furrow irrigation the whole object of the trash blanket was nullified as its function was to preserve moisture. He thought, however, that the trash blanket was helping to build up organic matter in the soil. It could, perhaps, be moved to alternate lines and irrigation water be led down the other lines. He foresaw that by ploughing in trash a very great nitrogen deficiency would be caused. This would probably lead to the necessity of heavy dressings of nitrogen. He had seen in experimental plots obvious nitrogen deficiencies when trash had been ploughed in.

Mr. Robertson inquired what the economics of spray irrigation as compared with furrow irrigation were. He wanted to know if any costs were available.

Mr. Pearson replied that as he was working with small plots it was not possible to work out costs per acre. He was hoping to obtain costs from a commercial concern, which was going to put 300 acres under spray irrigation. He said that the labour costs in spray irrigation were not as great as in furrow irrigation and pumping charges were not heavy.

Mr. King said that relative to the use of furrow irrigation with a trash blanket he had seen the short furrow irrigation method being utilised in Zululand. This resulted in irrigation being applied to small blocks at a time. Results, as judged by the appearance of the cane, appeared very satisfactory.

Prof. Theron said that the question of moisture and the availability of plant foods was a most complicated one. Under dry veld conditions they were at one time chary of using large quantities of nitrogeneous fertiliser, but subsequently it transpired that very heavy dressings could be applied and it was possible to obtain an eight-fold increase in yield. One could not judge the value of water unless in the comparison between various systems of irrigation, soil fertility was increased to its maximum potential in every case. Various types of blankets over the soil, including stone chippings, straw and malthoid have been investigated. Under the malthoid covering, where no extra water got into the soil, higher yields were obtained than with irrigation. Under the straw blanket they got their worst yields. This was probably due more to a poisoning effect than nitrogen deficiency. As far as the trash blanket was concerned he thought it a good idea to incorporate it, but he doubted that this could lead to any material increase in the organic matter in the soil. There were so many factors to be considered, however, that one could not afford to be dogmatic in the matter.

Mr. Pearson said that he too had been experimenting with various kinds of mulching, including bagasse, trash and grain bags. Moisture samples were taken beneath those various types of mulches. Very early on it was found that moisture was lowest in the samples taken from beneath the bagasse layer, owing to the bagasse absorbing water. Evaporation from the surface was a factor to be considered and also when the ground was kept bear, soil temperature increased enormously.