WATER DUTIES FOR SUGARCANE GROWN DURING SPRING AND AUTUMN CYCLES AT PONGOLA

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Abstract

To determine the optimum water duties for a spring crop cycle, the 4th and 5th ratoon crops of the water duty experiment at the Pongola Experiment Substation were used. In this experiment, which was established in 1966, 51 mm effective irrigation water was applied on minimum cycle times of 21, 28, 35 and 42 days. The 6th ratoon crop was cut back prematurely so that subsequent ratoon crops could be grown on an autumn cycle. Minimum cycle times of 14, 21, 28 and 35 days were tested for an autumn crop cycle, and the results obtained compared with those for the spring crop cycle. In all calculations the TAM of the soil was assumed to be 200 mm and the soil profile was not filled with water at the start of each crop. It was found that for summer crop cycles, a minimum cycle of 21 days was optimum for maximum tc/ha and ters/ha yields. For the autumn crop cycles the varying cycle times had little effect on the tc/ha and ters/ha yields during seasons of above average rainfall but, during seasons where the rainfall was below average for the months of high evaporative demand, the shorter cycle times tended to produce greater yields. A minimum 21 day cycle, applying 51 mm effective water at each irrigation is therefore recommended for both spring and autumn crop cycles, This represents a water duty of 2 844 ha/cumec where sprinkler irrigation is assumed to be 80% efficient and water is available continuously, or a water duty of 1 525 ha/cumec where surface irrigation is taken to be 60% efficient and available for only 120 hours per week. For maximum water use efficiency the minimum cycle time could be increased to 28 days for both spring and autumn crop cycles.

Introduction

A water duty was defined in the South African sugar industry as the area to be irrigated by one unit (e.g. one cumec) of water pumped or available at the water source, based on continuous operations, 7 days per week, 24 hours per day (Thompson and de Robillard[12]). More recently it has been convenient to modify this definition and to refer to "one unit of water available at the field edge." This change was introduced when surface irrigation became more common in the industry, and losses of water between the source and the field could be significant (Thompson[10]). One cumec of water is equivalent to 10 mm of water on 864 hectares in 24 hours.

When the sugar industry expanded into the new areas of Northern Natal, Swaziland and the Eastern Transvaal, no data were available regarding water duties under conditions where sugarcane could not be produced without irrigation. A conservative assumption was therefore made that an irrigation scheme should be designed to meet all, or nearly all, of the water requirements of the crop (Anon[2]). The results of continued experimentation at Pongola have illustrated that such conservatism was unwarranted and that water duties could be extended considerably without impairing the yield potential of the area.

The trial, which is to be discussed in this paper, has produced ten sets of results. The plant to 5th ratoon crops were all grown on a spring cutting cycle, while the 7th to 10th ratoon crops were grown on an autumn cycle. The conversion of one cycle to the other was carried out by cutting back the 6th ratoon crop.

The plant crop results, where 51 mm effective water was applied at minimum cycle times of 5, 7, 11 and 19 days, showed that, on the deep Makatini series soil, the application of 51 mm effective water every 19 days was sufficient to produce potential yields in a year of well distributed rainfall (Thompson and Boyce[11]). This treatment represents a water duty of 1 379 ha/cumec where water is available for 120 hours per week and is used with an efficiency of 60% (surface irrigation). By increasing the efficiency to 80% (sprinkler irrigation) and operating continuously, however, this water duty could be increased to 2 573 ha/cumec.

During the 1st ratoon crop, minimum cycle times of 7, 14, 21 and 28 days were compared. The results showed that maximum yields of sucrose per hectare could be produced with the application of 51 mm effective water every 21 days, even in a season with a well distributed but relatively low rainfall of 354 mm (Boyce[5]). Boyce[5] stated that, on deep soil profiles at Pongola, there appears to be potential for maximum farm productivity by adjusting the water duties to approximately 1 525 ha/cumec for surface irrigation and 2 844 ha/cumec for sprinkler irrigation, provided the soil profile is refilled during the period of incomplete canopy of the following crop.

Similar observations were made during the 2nd ratoon crop (Anon[2]) and 3rd ratoon crop (Anon[3]) where 51 mm effective water was applied on minimum cycle times of 21, 28, 35 and 42 days.

When the trial was converted to an autumn cutting cycle, the crop was expected to be well grown during the period of maximum evaporative demand, i.e. December to February, and for this reason it was predicted that a shorter irrigation cycle time might be optimum by comparison with that of the spring cycle. The aim of this paper has therefore been to compare the crop responses, in yields of tc/ha and ters/ha, to the different irrigation cycle times when these are imposed during different cutting cycles.

Procedure

The experiment was established in 1966 on a Makatini sandy clay soil at the SASA Pongola Experiment Substation. The mechanical analyses and the moisture characteristics of the soil, to a depth of 180 cm, have been reported by Thompson and Boyce[11].

The variety NCo 376 was planted in the trial, which consisted of six replications of four treatments in a randomised block design. A comparison of "trashing" and "burning" was introduced in the 1st ratoon crop and continued through to the 5th ratoon crop. In this paper, however, only the "burning" results have been considered in respect of the 4th and 5th ratoon crops.

The total available moisture (TAM) present in the soil profile was assumed to be 100 mm for the plant (Thompson and Boyce[11]), the 1st (Boyce[5]) and 2nd (Anon[1]) ratoon crops, 150 mm for the 3rd ratoon crop (Anon[3]) and 200 mm for all subsequent ratoon crops. The soil profile was saturated with water at the start of the plant to 3rd ratoon crops, but not at the start of the remaining ratoon crops (Thompson[10]). Therefore, in order to make comparisons of crop responses to different water duties for different cutting cycles, only those crops which had been subjected to the same conditions (assumed TAM of 200 mm and not filling the profile) have been included in this paper, viz. the 4th and 5th ratoon crops of the spring cycle and the 7th to 10th ratoon crops of the autumn cycle.

The moisture characteristics of the Makatini series soil, as described by Thompson and Boyce [11] indicated that the mean TAM for a 180 mm profile was 362 mm. Thompson[9] has explained in some detail how difficult it is to establish a precise TAM value, as the "effective" rooting depth is difficult to measure. The TAM of 200 mm used in this paper was arbitrarily chosen and represents the amount of water held in the top metre of soil. The principle of equal availability of soil moisture was adhered to when using the profit and loss account, even when the apparent depletion exceeded the estimated TAM.

The treatments were identified in terms of the minimum number of days in which an irrigation cycle could be completed when 51 mm effective water was applied per cycle. The minimum cycle times tested during the 4th and 5th ratoon crops were 21, 28, 35 and 42 days, while for the 7th and 8th ratoon crops the minimum cycle times were 14, 21, 28 and 35 days. For the 9th and 10th ratoon crops the 35 day cycle was replaced by a 5 day cycle at half the application rate, i.e. 25 mm effective water at each application. The results obtained from the 5 day cycle have not been included in this paper. The conversion of the cycle time, in days, to water duties in hectares per cumec was carried out using the following equation:

$$\text{Water duty} = \frac{\text{cycle time (days) x 8 640}}{\text{gross irrigation (mm)}} \text{ ha/cumec}$$

The cycle times and the corresponding water duties that have been compared in this study are presented in Table 1.

TABLE 1

Minimum cycle times per 51 mm application of effective water, and the equivalent water duties for selected irrigation delivery efficiencies, for the treatments imposed on the crop growing under spring and autumn cutting cycles.

Minimum cycle time (days)	Water duties, ha/cumec	
	Overhead irrigation	Surface irrigation
	80% effective 168 hrs/week	60% effective 120 hrs/week
14	1 896	1 016
21	2 844	1 525
28	3 792	2 033
35	4 740	2 541
42	5 688	3 049

To apply 51 mm effective water by sprinkler irrigation (80% efficient) 63,8 mm gross water must be applied; for surface irrigation (60% efficient), 85 mm gross water must be applied.

Irrigation was applied to individual plots by means of perf-o-rain pipes as described by Thompson and Boyce[11] who also described how the irrigation could be controlled by means of a soil moisture profit and loss account. A continuous estimate of the available soil moisture deficit was made by keeping a daily soil moisture profit and loss account for each treatment, taking rainfall, irrigation and evapotranspiration into account. All rain was credited to the soil moisture profit and loss account up to field capacity, any excess being regarded as lost due to runoff or deep percolation. The daily estimates of evapotranspiration used were those reported by Thompson[9].

TABLE 2

The harvest dates and the crop age at harvest for the crops grown on a spring and autumn cutting cycle.

Cycle	Crop	Growth Period	Crop age (months)
Spring	R4	18.11.70 - 18.10.71	11,0
	R5	18.10.71 - 18.10.72	12,0
Autumn	R7	11.5.73 - 3.6.74	12,7
	R8	3.6.74 - 10.6.75	12,2
	R9	10.6.75 - 11.5.76	11,0
	R10	11.5.76 - 7.6.77	12,9

The harvest dates and the crop age at each harvest are presented in Table 2.

Results and Discussion

Rainfall and irrigation data

The monthly rainfall for each crop, the long term monthly mean evaporation from a class A pan and the long term monthly mean rainfall are presented in Table 3.

TABLE 3

The monthly rainfall for the 6 crops, the long term monthly mean evaporation from a class A pan (E_0) and the long term monthly mean rainfall.

Month	Monthly E (mm)	L.T.M. (mm)	Monthly rainfall (mm)					
			R 4	R 5	R 7	R 8	R 9	R10
Oct	189,1	71,5		57,1				
Nov	189,0	93,5	82,1	189,9				
Dec	204,6	101,1	51,2	134,8				
Jan	235,6	106,4	78,6	123,6				
Feb	184,8	90,7	87,8	104,6				
March	195,3	64,4	87,6	74,3				
April	144,0	45,1	68,6	20,5				
May	117,8	24,7	23,6	51,7	1,5			42,5
June	108,0	10,9	0,7	3,7	1,0	13,6	7,4	0,0
July	102,3	10,6	3,8	11,7	1,2	30,6	3,9	0,0
Aug	127,1	11,8	2,9	0,0	42,0	0,0	0,0	2,9
Sept	183,0	39,2	24,8	5,1	139,9	0,0	128,8	0,3
Oct	189,1	71,5	57,1	23,1	58,1	43,2	22,6	112,3
Nov	189,0	93,5			142,8	153,6	94,4	62,4
Dec	204,6	101,1			86,9	137,0	111,9	31,0
Jan	235,6	106,4			198,2	156,3	116,4	150,6
Feb	184,8	90,7			2,6	147,9	100,3	117,7
March	195,3	64,4			42,2	19,4	76,8	52,4
April	144,0	45,1			79,0	64,8	29,7	2,5
May	117,8	24,7			7,0	6,2	42,5	16,7
June	108,0	10,9						4,3
Rainfall total for season			568,8	800,0	802,4	772,6	733,9	595,6
L.T.M. total for season			669,9	741,4	694,6	669,9	669,9	705,5

From the rainfall data that have been presented, it can be seen that the rainfall recorded for the 4th and 10th ratoon crops was considerably less than the long term mean and that, in both cases, the rainfall recorded during the high evaporative demand month of December was extremely low. Under these conditions one would expect the shorter cycle times to produce greater yields than did the longer cycle times. For all the other crops the recorded rainfall was greater than the long term mean.

The effective rainfall, irrigation and total water credited to each treatment are presented in Table 4.

The total rainfall and irrigation credited to each treatment of each crop were effective in all cases except the 14 day cycle of the 7th ratoon crop (irrigation 98% effective, rain 88% effective) and the 8th ratoon crop (irrigation 99% effective and rain 83% effective). This was the result of the above average rainfall recorded during the months of September, November and January for the 7th ratoon crop, and during November, December and February for the 8th ratoon crop.

Presented in Table 5 are the drying off periods and the number of stress days experienced during the season for the different cycle times of the different crops.

For the purpose of this paper, a stress day was arbitrarily defined as a day on which the soil moisture deficit for a particular treatment exceeded the TAM value of 200 mm. The number of stress days therefore only gives an idea of the amount of stress suffered by the crop, but no indication of the degree of stress suffered.

TABLE 4

The effective rainfall, irrigation and total water credited to each treatment for the six crops under consideration.

Crop	Water source	Effective Water (mm) 14 day	21 day	28 day	35 day	42 day
R 4	Rain Irrigation Total		493,0 750,0 1 243,0	493,0 500,0 993,0	493,0 450,0 943,0	493,0 400,0 893,0
R 5	Rain Irrigation Total		664,0 700,0 1 364,0	664,0 600,0 1 264,0	664,0 500,0 1 164,0	664,0 350,0 1 014,0
R 7	Rain Irrigation Total	688,8 1 084,4 1 773,2	779,4 761,0 1 540,4	779,4 561,0 1 340,4	779,4 511,0 1 290,4	
R 8	Rain Irrigation Total	630,2 990,0 1 620,2	762,6 700,0 1 462,6	762,6 550,0 1 312,6	762,6 450,0 1 212,6	
R 9	Rain Irrigation Total	733,9 800,0 1 533,9	733,9 650,0 1 383,9	733,9 500,0 1 233,9		
R10	Rain Irrigation Total	548,8 922,0 1 470,8	548,8 672,0 1 220,8	548,8 572,0 1 120,8		

TABLE 5

The drying off period and the number of stress days experienced during the season for the different cycle times of the different crops.

Crop	Drying off period (days)					Stress days				
	14 day	21 day	28 day	35 day	42 day	14 day	21 day	28 day	35 day	42 day
4th ratoon	–	38	33	27	25	–	18	79	91	108
5th ratoon	–	41	34	32	23	–	41	83	107	145
7th ratoon	44	46	34	28	–	0	15	53	62	–
8th ratoon	62	63	61	67	–	17	50	86	101	–
9th ratoon	102	62	62	–	–	25	21	53	–	–
10th ratoon	90	89	99	–	–	62	91	105	–	–

TABLE 6

The yields in tc/ha and tc/ha/100 mm effective water obtained from different irrigation cycle times for the different crops.

Cycle	Crop	tc/ha 14 days	21 days	28 days	35 days	42 days	C.V. %	S.E. treatment mean	L.S.D. 0,05	0,01
Spring	R4	-	148	121	115	96	10,0	5,1	22	31
	R5	-	149	140	134	103	13,3	7,1	31	43
	Mean	-	149	131	125	100				
Autumn	R 7	138	138	135	130	-	6,8	3,8	11,6	16,2
	R 8	136	123	124	124	-	7,8	4,1	12,5	17,6
	R 9	141	138	127	-	-	7,4	4,1	13,0	18,0
	R10	136	108	123	-	-	7,7	4,1	12,5	17,6
	Mean	138	127	127	125*	-				

Cycle	Crop	tc/ha/100 mm effective water 14 days	21 days	28 days	35 days	42 days
Spring	R 4	-	11,6	12,4	12,8	11,9
	R5	-	10,3	10,9	11,2	11,0
	Mean	-	10,9	11,6	12,0	11,5
Autumn	R 7	7,8	9,0	10,1	10,1	-
	R 8	8,4	8,4	9,4	10,2	-
	R 9	9,2	10,0	10,3	-	-
	R10	9,2	8,8	11,0	-	-
	Mean	8,7	9,1	10,2	10,6*	-

* Mean adjusted to compensate for the fact that the 35 day cycle was not tested during the 9th and 10th ratoon crops.

Tons cane yield

Statistically significant differences were found between the tc/ha yields obtained from the different cycle times for the 4th, 5th and 10th ratoon crops (Table 6).

For the spring cycle crops, the tc/ha yields declined with increasing cycle times, the yield response to the 21 day cycle being greater in the 4th ratoon crop than in the 5th ratoon crop. This is not surprising when the rainfall data discussed earlier are considered and also the fact that the 21 day cycle of the 4th ratoon crop experienced far fewer stress days during the season than did this cycle during the 5th ratoon crop. Although the TAM and the soil moisture status at the start of these crops differed from those of the preceding crops, these results confirm those reported by Thompson and Boyce[11], Boyce[5] and Anon.[2,3] On the other hand, the tc/ha yield results obtained for the 7th, 8th and 9th ratoon crops (autumn crop cycle) showed no statistical yield response to the different cycle times. The inconsistent results obtained for the 10th ratoon crop, where the 21 day cycle yielded less than either the 14 or 28 day cycle, are difficult to explain. A possible explanation is that, because of the particular timing of the cycles, the 21 day cycle received only one irrigation during December and the 28 day cycle two, and that December, a high evaporative demand month, was a dry month from a rainfall point of view. This is therefore an example of how rainfall distribution can affect the yield response obtained for a particular cycle time.

Water use efficiency, as measured by the tc/ha/100 mm effective water yields, increased with increasing cycle times up to the 35 day cycle for both the spring and autumn growth cycles, The tc/ha/100 mm effective water yields were, however, greater for the spring cycle crops than for the autumn cycle crops (Table 6).

Relationship between tons can and effective water

The regression equations and correlation coefficients describing the relationship between the tc/ha yield and the effective water for the different crops are presented in Table 7.

The analyses were not very precise as only four points were used in each analysis. The results do, however, confirm the tc/ha yield results that have already been mentioned, viz. that there was a greater yield response to the shorter irrigation cycle times for the spring cycle crop than for the autumn cycle crop.

ERS % cane

Except for the 4th (a below average rainfall season) and 7th (an above average rainfall season) ratoon crops, no statistically significant differences were found between the ers % cane contents obtained for the different cycle times (Table 8).

The high tc/ha yield and the low number of stress days experienced by the 21 day cycle of the 4th ratoon crop indicate that the low ers % cane obtained for the treatment was the result of the cane being immature. On the other hand the low tc/ha yield and the large number of stress days recorded for the 42 day cycle of the 4th ratoon crop indicate that the low ers % cane for the treatment might be the result of cane deterioration having taken place. The 14 day cycle of the 7th ratoon crop experienced no stress during the season and the low ers % cane value was no doubt due to the cane being immature.

Tons ers yield

The yields in ters/ha and ters/ha/100 mm effective water, are presented in Figures 1 and 2.

The fact that the irrigation cycle times had little effect on the ers % cane values means that the ters/ha responses to the different treatments were, in most cases, similar to those of the tc/ha yields. A notable exception is that the ters/ha yield response to the 21 day cycle of the 4th ratoon crop was less than the tc/ha yield response. Similarly, the moisture use efficiency patterns in terms of ters/ha/100 mm effective water, were similar to those obtained for the moisture use efficiency where it was expressed in tc/ha/100 mm effective water.

According to the LSD values, statistically significant differences were obtained between the ters/ha yields of the different

TABLE 7

Regression and correlation constants for relationships between tc/ha and effective water, of the form tc/ha = a + b (effective water).

Crop	No. of observations	a	b	Correlation Coefficient	Significance
4th ratoon	4	- 12,3	0,130	0,96	P > 0,05
5th ratoon	4	- 12,7	0,120	0,96	P > 0,05
7th ratoon	4	114,7	0,014	0,80	NS
8th ratoon	4	89,2	0,027	0,77	NS
9th ratoon	4	83,2	0,037	0,88	NS
10th ratoon	4	40,7	0,065	0,85	NS

TABLE 8

The ers %c values obtained from different irrigation cycle times for the different crops.

Cycle	Crops	ers % cane					C.V. %	S.E. treatment mean	L.S.D.	
		14 days	21 days	28 days	35 days	42 days			0,05	0,01
Spring	R 4	-	11,9	13,4	13,1	12,1	3,6	0,26	0,80	1,10
	R 5	-	11,2	11,9	11,8	11,3	7,0	0,45	1,40	1,90
	Mean	-	11,6	12,7	12,5	11,7				
Autumn	R 7	9,8	10,8	11,0	11,2	-	6,9	0,30	0,94	1,31
	R 8	11,1	11,0	11,1	10,6	-	4,2	0,19	0,58	0,82
	R 9	8,0	7,8	7,7	-	-	6,9	0,22	0,70	1,00
	R10	12,2	12,5	12,4	-	-	4,8	0,24	0,74	1,04
	Mean	10,3	10,5	10,6	10,5*	-				

* Mean adjusted to compensate for the fact that the 35 day cycle was not tested during the 9th and 10th ratoon crops.

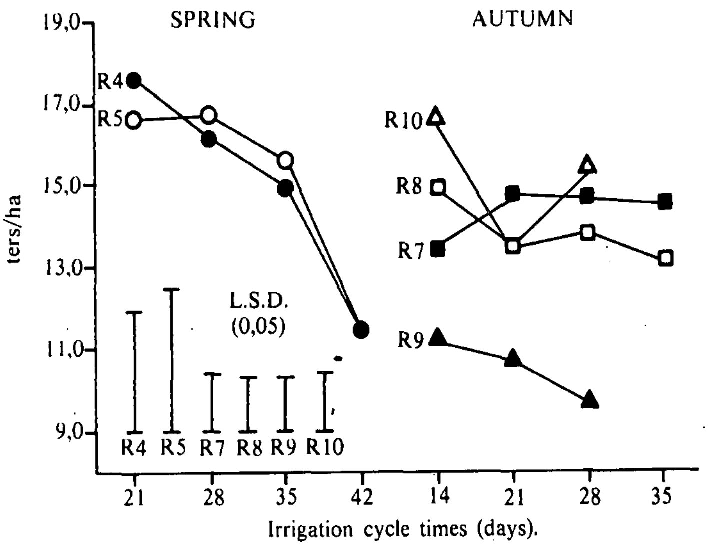

Figure 1 The ters/ha yields obtained from different irrigation cycle times for different crops grown during Spring and Autumn cutting cycles.

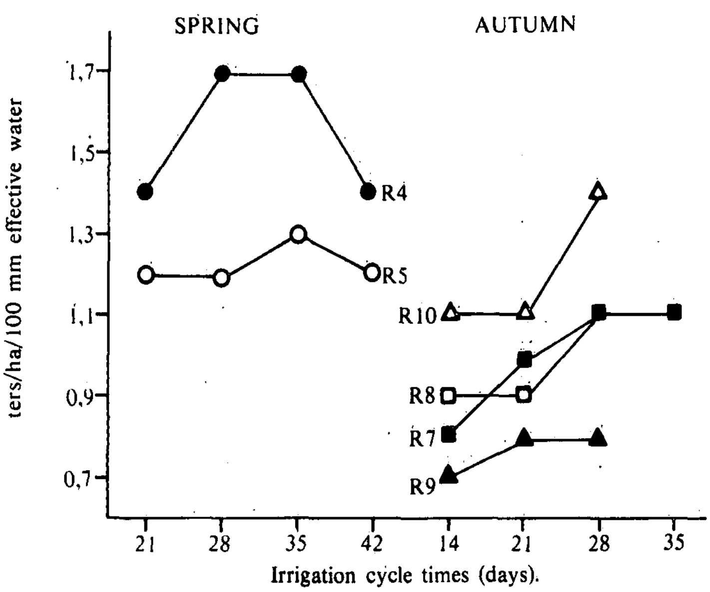

Figure 2 The ters/ha/100 mm effective water yields obtained from different irrigation cycle times for different crops grown during Spring and Autumn cutting cycles.

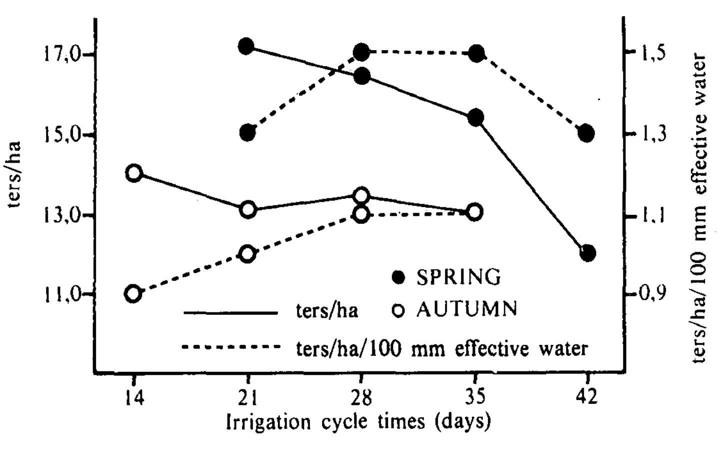

Figure 3 Mean yield in ters/ha and ters/ha/100 mm effective water for a Spring and Autumn crop cycle (35 day mean for Autumn crop adjusted to compensate for the fact that this cycle was not tested during the 9th and 10th crops).

cycle times for the 8th and 9th ratoon crops. The F values for these analyses were, however, not statitstically significant. As the treatment comparisons were not *a priori* comparisons it is statistically incorrect to state that the yields of these treatments were statistically different.

In order to determine whether or not the same cycle times could be recommended for an autumn crop cycle as for a spring crop cycle, the mean ters/ha and ters/ha/100 mm effective water yields for the 4th and 5th ratoon crops (spring cycle) were compared with the mean yields of the 7th to 10th ratoon crops (autumn cycle). This comparison is presented schematically in Figure 3.

It can be seen that the ters/ha yields for the spring crop cycle decreased with increasing cycle times, while the ters/ha yields for the autumn crop cycle were relatively unaffected by the cycle times. The mean ters/ha yield of the 14 day cycle of the autumn crop cycle tended to be greater than that of the other cycle times; but this response was largely due to the superiority of the 14 day cycle in the 10th ratoon crop (a low rainfall season).

Except where the cycle time was extremely long (42 days), the mean ters/ha yields from spring cycle crops were higher than those from winter cycle crops. Although this trend is real one, the lower mean yields of the autumn cycle crop in Figure 3 have been exaggerated by the low ers % cane values obtained for the 9th ratoon crop.

From the moisture use efficiency data it would appear that the spring cycle crops were more efficient in producing sucrose than were the autumn cycle crops, the summer cycle producing a maximum yield of 1,5 ters/ha/100 mm effective water and the autumn cycle a maximum yield of 1,1 ters/ha/100 mm effective water. For both crops cycles the maximum water use efficiency was obtained with cycle times of 28 and 35 days.

Discussion

The trial was established on a soil with a large TAM value and the results presented can therefore be extrapolated only to sugarcane growing on soils of a similar TAM value. According to Perfect[8], information which is at present being obtained from a soil survey in the Pongola area (8 826 hectares have been surveyed out of a quota area of 11 625 hectares) indicates that 55% of the soils in this area are alluvia and that 17% of the soils have dolerite as a parent material. From the completed survey of the Nkwalini Valley it was found that 35% of the soils were alluvia and that 14% of the soils were derived from dolerite. Data presented by MacVicar and Perfect[7] show that 13% of the soils in the Eastern Transvaal are alluvia, while certain of the soil series derived from Swaziland basic rocks (38,5%) and Basalt and Diabase (28%) are more than one metre in depth. It would therefore appear that the results presented in this paper could be applied to a considerable proportion of the sugarcane grown in the irrigated areas of the South African sugar industry, particularly in the Pongola area.

For the spring cycle crops, maximum yields were obtained where 51 mm effective water was applied on a 21 day cycle. The yields obtained from this treatment were similar to those of the 21 day cycle for the plant to 3rd ratoon crops where the soil profile had not been filled at the start of the crop. It would therefore appear that, for a spring crop cycle, filling or not filling the soil profile at the start of a crop will not have much effect on the yields that will be obtained. Results obtained from an adjacent trial have shown that there was no statistical evidence of a difference between filling and not filling the soil profile for an autumn cycle crop which received 61 mm effective water on a minimum 25 day cycle (equivalent to 51 mm effective water on a minimum 21 day cycle) (Anon[4]). This was the case where the drying-off period varied from 59 to 119 days and also where the rainfall recorded for the season was considerably lower than the long term mean.

A problem in interpreting these results is that each treatment represented only one field in any one irrigation system, e.g. the 21 day cycle treatment represented only one field in a system of 21 fields. Therefore the timing of an irrigation, in relation to rainfall, could in some cases be critical and could give rise to yield responses which were not representative of the entire system. This appears to have been the case for the 21 day cycle of the 10th ratoon crop.

The results presented indicate that the application of 51 mm effective water, on a minimum 21 day cycle, can safely be recommended for spring cycle crops. This represents a water duty of 2 844 ha/cumec where sprinkler irrigation is practised 168 hours per week, or a water duty of 1 525 ha/cumec where surface irrigation is practised 120 hours per week. From a practical point of view, any single farm would have sugarcane growing on both a spring and an autumn cycle, and it would be convenient to have the whole irrigation system on the same minimum cycle time. As the yield responses for the autumn cycle crop were relatively unaffected by the varying cycle times, it is felt that the same irrigation cycle time of 21 days recommended for the spring crop cycle should be recommended for the autumn crop cycle. During seasons of adequate rainfall this cycle time could be increased to 28 days, but during seasons where the rainfall was below average for the high evaporative demand months, the shorter cycle times would be beneficial.

In his situation survey of Pongola, Havenga[6] stated that the average irrigation cycle times for sprinkler irrigation in the area are 14 days during summer and 24 days during winter, while the average net applications are approximately 45 mm, although these applications vary between 24 and 60 mm per application. As a water duty is determined by the period of maximum water demand, the average water duty that the Pongola scheme is irrigating to is 2 150 ha/cumec when sprinkler irrigation is being used. This water duty is considerably lower than the one which has been recommended.

For maximum water efficiency the minimum cycle time could be increased to 28 days for both the spring and autumn cycle crops. The recommended water duties in this case would be 3 792 ha/cumec for sprinkler irrigation and 2 033 ha/cumec for surface irrigation.

Conclusions

It can be concluded that the application of 51 mm effective water, on a minimum 21 day cycle, can safely be recommended for both spring and autumn cycle crops. This represents a water duty of 2 844 ha/cumec where sprinkler irrigation (80% efficient) is practised 168 hours per week, or a water duty of 1 525 ha/cumec where surface irrigation (60% efficient) is practised 120 hours per week.

The recommendation could be applied to a considerable proportion of the sugarcane grown in the irrigated areas of the South African Sugar Industry. In the Pongola area approximately 72% of the area could be irrigated to the water duty recommended.

It can also be concluded that filling or not filling the soil profile with water at the start of the crop will have no effect on yields for either spring or autumn cycle crops and it is not necessary to take into account the water required to fill the soil profile when determining the water duty.

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