COMPARISONS OF THE GROWTH OF PLANT AND FIRST RATOON CROPS OF SUGARCANE AT PONGOLA

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Abstract

The growth of plant and first ratoon crops of variety N14 in adjacent fields at Pongola started on 12 November 1986. Plots were harvested at intervals during the development of the crops, and the results were compared with those obtained for variety NCo376 when it was planted on the same site in 1967. Adequate amounts of fertilizer and irrigation water were applied to all of the crops. The plant crop of N14 appeared to perform better than had the NCo376 19 years previously. The first ratoon crop of N14 produced a green leaf canopy much faster than did the plant crop. Initially it accumulated above-ground dry matter at a faster rate than the plant crop, but subsequently at a slower rate so that yields after 334 days were similar. The effects of respiration losses are proposed as a cause of this result and illustrated. Photosynthetic efficiency in terms of above-ground dry matter production in relation to total incident radiation showed the plant crop of N14 (1,8%) to be superior to the first ratoon crop (1,7%), and both were superior to the plant crop of NCo376 (1,6%).

Introduction

An irrigated field at Pongola, in which 3 weighing lysimeters were located, was planted to sugarcane on 12 November 1986. So that adjacent fields would constitute suitable boundary areas for the lysimeter experiment, the field immediately west of the lysimeter field was planted on the same day, and a plant crop in the field immediately to the east was harvested on the previous day. The variety N14 was used in all 3 fields. Hence an opportunity arose to study the concurrent development of plant and first (1st) ratoon crops of this variety.

The same 3 fields were planted with variety NCo376 on 12 November 1967 (Thompson[6]). The field to the east of the lysimeter field was used as a growth analysis experiment, 4 replications of plots, each 16,7 m² in extent, being harvested at approximately monthly intervals from January 1968 onwards. There was thus also an opportunity to compare the growth of a plant crop of NCo376 in one season with that of N14 in another season, the planting date being the same for both crops.

Methods

A block comprising 11 rows of cane 70 m long at the southern end of the lysimeter field was set aside for this growth analysis trial. Pegs were located at 10 m intervals along each of the inner 9 rows. The 10 m at the southern end of the field was treated as a guard area. Hence there were 6 single row plots identified in rows 2 to 9 of the block, provision thus being made for as many as 6 times of harvest. On 21 January 1987, the first harvesting was carried out by removing the cane from random single row plots in each of the 9 rows. The length of row harvested in each instance was 2,44 m (the length of each of the weighing lysimeters), and this was established precisely by means of a metal frame being placed on the ground next to the row, and two pointed arms 2,44 m apart being pushed into and through the cane row to define the plot to be harvested.

In January all shoots in the 2,44 m lengths of row were cut carefully at ground-level. Small amounts of dead material were not separated from the green foliage, and short lengths of apical stem which protruded above-ground also formed part of the harvested crop.

Harvesting was subsequently carried out at approximately 2-monthly intervals. The harvesting dates and age of the crop when harvested were as follows:

Date (1987)	Age of crop (days)
21 January	70
17 March	125
19 May	188
21 July	251
12 October	334

When harvesting took place from March onwards, only 4 plots were harvested on each occasion because of the amount of work involved. These were taken regularly from rows 3, 5, 7 and 9. All dead leaves and shoots (trash) were first removed from the plot and placed in pre-weighed polythene bags. The stalks and shoots were then cut carefully at ground-level and delivered immediately to the millroom for weighing. The trash in the polythene bags was weighed and dried. The stalks and shoots were separated into foliage (leaves and sheaths) and stalks, including the apical meristem. The two components were weighed separately. The foliage was chopped in a chaff cutter and subsamples were taken to determine dry matter contents. The stalks were then disintegrated and subsamples were taken to determine dry matter contents. Drying of subsamples was carried out immediately after weighing the wet material at Pongola so that respiration would be arrested.

After lodging occurred on 10 April 1987, sites for the 2,44 m lengths of row to be harvested were selected from within the pre-determined 10 m boundaries so that only erect cane was harvested. This was done because the cane in the lysimeters remained erect (Thompson[7]).

When the plant crop of the experiment was harvested on 12 October 1987, the stalks were divided into two parts by being snapped at the natural breaking point. The bottom parts (cane stalk) and the top parts (apex) were weighed and analysed separately so that harvestable cane yields could also be estimated. Trash and subsamples of foliage and stalk were dried to a constant weight at Mount Edgecombe on each occasion.

The area at the southern end of the field of 1st ratoon N14 cane on the eastern side of the lysimeter field was used to provide plots of the ratoon crop that were comparable with the adjacent plant cane plots. Exactly the same procedures were followed at each time of harvest to obtain measurements of yield from a 1st ratoon crop.

The 3 fields of N14 were the same size and shape. Each was approximately 0,4 ha in extent. The layout and irrigation procedures were the same as those described previously

for the NCo376 crop (Thompson[6]). The plant crop of N14 received 53 kg nitrogen (N), 18 kg phosphorus (P), and 88 kg potassium (K) ha^{-1} in the furrow and a topdressing of 32 kg N and 64 kg K ha^{-1} on 19 December 1986. The 1st ratoon crop of N14 received 172 kg N and 130 kg K ha^{-1} on 17 November 1986, and a further 23 kg N ha^{-1} on 23 January 1987.

When the fields were harvested in October 1987, the total amount of cane from each field was weighed on the farm scale. Vertical ground-cover was measured in the plant and 1st ratoon crops on a number of occasions until the estimate exceeded 90%. Monthly stalk and shoot counts were made from January through April 1987. The leaf area index (LAI) was estimated for the two crops on 19 June 1987 when they were both 189 days old. All green leaves were removed from 2,44 m of cane row. These were weighed before a subsample was taken, weighed, and the leaf area determined by means of a Licor 3 000 leaf area meter. The results were used to estimate leaf area ha^{-1} and LAI.

Sunshine hours were recorded daily on the nearby meteorological site so that incident radiation could be calculated. Maximum and minimum daily temperatures were used to calculate mean daily temperatures for each growth period, from which amounts of respiration could be estimated.

Results and discussion

On 3 January 1987, when the plant and 1st ratoon crops of N14 were 53 days old, they appeared as shown in Figure 1. The plant crop in the foreground had developed so much less than the 1st ratoon crop in the background that this growth analysis experiment was conceived and the first harvesting took place 17 days later. Figure 2 shows the rates of vertical ground-cover achieved by the 2 crops, the 1st ratoon being fully canopied some 22 days ahead of the plant crop.

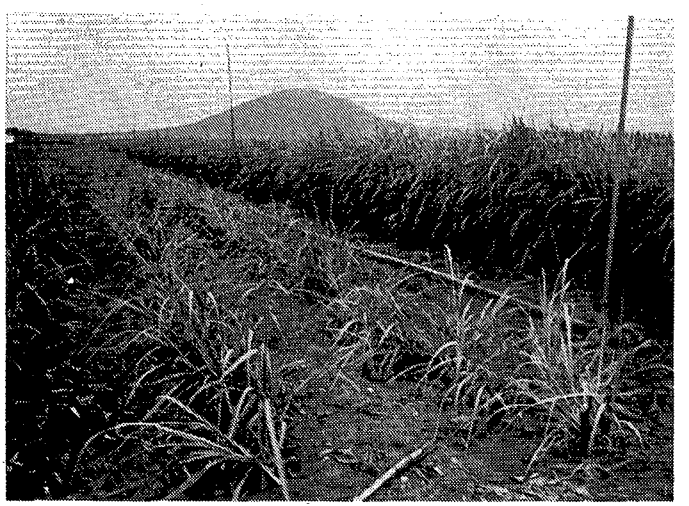

FIGURE 1 Plant (foreground) and 1st ratoon (background) crops of N14 photographed on 3 January 1987 when they were both 53 days old.

In Table 1 the amounts of dry matter present in diffferent parts of the plant and ratoon crops at the times of successive harvestings are shown. It can be seen that, despite its much slower start, the plant crop had accumulated as much dry matter as the 1st ratoon when they were both 334 days old.

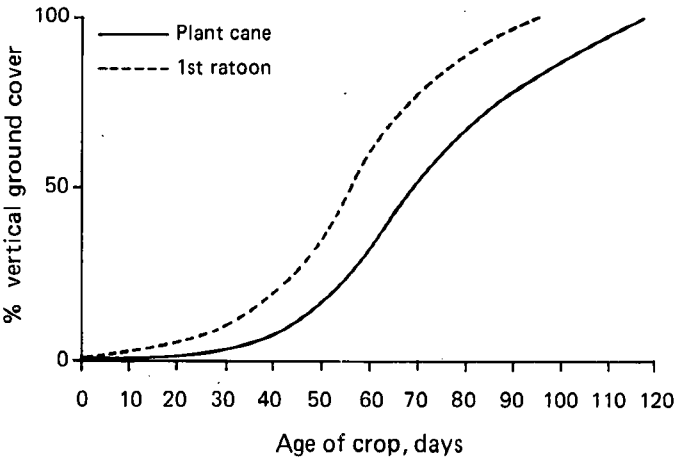

FIGURE 2 Vertical ground-cover development of a plant crop and a 1st ratoon of variety N14, both started on 12 November 1986 at Pongola.

Table 1

Dry matter production in foliage, stalks, trash, and roots of a plant crop and of a 1st ratoon crop of N14 during 334 days

Crop	Date	Age of crop (days)	Accumulated t dm ha^{-1}					
			Foliage	Stalks	Trash	Total above-ground	Roots*	Grand total
Plant	20.01.87	70	1,65	--	—	1,65	0,16	1,81
	16.03.87	125	9,61	8,60	0,96	19,17	1,92	21,09
	15.05.87	188	8,88	21,17	4,80	34,85	3,48	38,33
	20.07.87	251	9,73	32,24	6,42	48,39	4,84	53,23
	11.10.87	334	9,90	42,47	8,47	60,84	6,08	66,92
1st ratoon	20.01.87	70	7,17	--	—	7,17	0,72	7,89
	16.03.87	125	11,80	13,93	2,75	28,48	2,85	31,33
	15.05.87	188	8,28	22,52	5,89	36,69	3,67	40,36
	20.07.87	251	8,52	33,91	7,32	49,75	4,98	54,73
	11.10.87	334	8,67	40,16	8,48	57,31	5,73	63,04

* Dry matter in roots estimated to be 10% of above-ground dry matter

The proportions of dry matter in stalks, foliage, and trash of comparable plant crops of NCo376 and N14, and the 1st ratoon crop of N14 at the time of harvest were:

	NCo376	N14	
	P	P	1R
Stalk	69	70	70
Foliage	19	16	15
Trash	12	14	15

Figure 3 illustrates the relative performances of the plant and 1st ratoon crops of N14 during successive periods in terms of above-ground dry matter produced m^{-2} d^{-1}. The plant crop of NCo376 was harvested at different intervals in 1967–68 and the data for this crop are also plotted in Figure 3.

In an attempt to explain the different performances of the plant and ratoon crops of N14, which had both received adequate water and nutrition, reference was made to Glover.[2] Gross assimilation was calculated based on the following assumptions:

(i) that the proportion of incident radiation (R_I) intercepted by the crop foliage was proportional to the average percentage of vertical ground-cover during each period

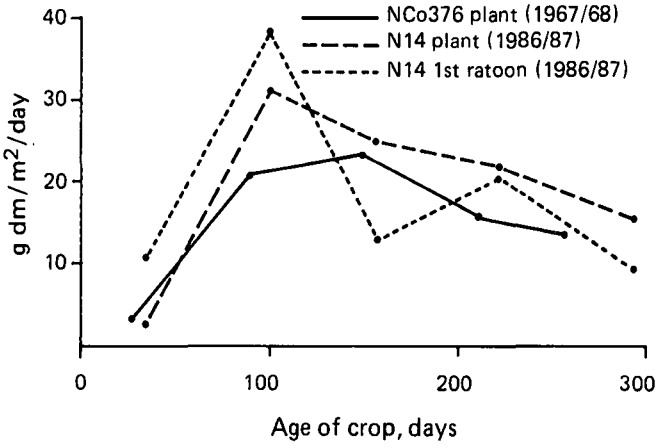

FIGURE 3 Above-ground dry matter production by plant crops of NCo376 and N14 and a 1st ratoon crop of N14 during successive periods of growth.

(ii) that the heat of combustion of 1 g of dry matter (CH_2O) was 4 200 calories

(iii) that the usable energy for photosynthesis is 8% of R_I (Monteith[4])

(iv) that the efficiency of sugarcane leaves in capturing photosynthetically active R_I is 70% on average

(v) that N14 performs at a level which is 75% of the potential proposed by Glover.[2]

The results of these calculations are given in Table 2 for the plant and 1st ratoon crops. The amounts differ only due to differences in the percentages of canopy formation and the resultant differences in radiation interception.

Respiration (R_s) of sugarcane plants was measured by Glover[2] and the amounts could be calculated from the following equations:

$$R_s \text{ mg } (CH_2O) \text{ min}^{-1} \text{ kg}^{-1} \text{ dm (stalks)} = 0{,}2495T°C - 3{,}046 \quad (1)$$

$$R_s \text{ mg } CH_2O \text{ min}^{-1} \text{ kg}^{-1} \text{ dm (foliage)} = 3(0{,}2495T°C - 3{,}046) \quad (2)$$

R_s of roots was assumed to be 10% of that of the above-ground parts of the crop. Based on these relationships, R_s was calculated from mean air temperatures for each period at Pongola, and the mean amounts of dry matter present during each period. It was assumed that there was a linear increase in the amount of dry matter accumulated during each period. R_s subtracted from estimated dry matter production (Table 2) provided an estimate of net assimilation for each period. The results are given in Table 3, and the measured and estimated amounts of accumulated dry matter for the plant crop are shown in Figure 4.

Table 2

Theoretical amounts of dry matter which could be produced by a plant and 1st ratoon crop of N14 at Pongola during successive periods

Period		No of days	Rad (R) ly d^{-1}	Plant			1st ratoon		
From	To			Ave % canopy	Gross t* dm ha^{-1}	Est t** dm ha^{-1}	Ave % canopy	Gross t* dm ha^{-1}	Est t** dm ha^{-1}
12.11.86	20.01.87	70	532	12	8,52	4,47	24	17,04	8,95
21.01.87	16.03.87	55	524	82	44,97	23,61	96	52,65	27,64
17.03.87	18.05.87	63	412	100	49,46	25,97	100	49,46	25,92
19.05.87	20.07.87	63	342	100	40,99	21,52	100	40,99	21,52
21.07.87	11.10.87	83	377	100	58,85	30,90	100	58,85	30,90
12.11.86	11.10.87	334	432	–	202,79	106,47	–	218,99	114,98

* Gross t dm $ha^{-1} = \frac{R_I}{4\,200} \times \frac{8}{100} \times$ % canopy $\times$ no of days $\times 10^2$

** Estimated t dm ha^{-1} = Gross t dm $ha^{-1} \times 0{,}70 \times 0{,}75$

0,70 = assumed photosynthetic efficiency of sugarcane leaves

0,75 = assumed performance of a sugarcane crop relative to theoretical potential

Table 3

Estimated net assimilation by a plant crop and 1st ratoon crop at Pongola during successive periods

Crop	Period	Mean T°C	Respiration (R_s) (t dm ha^{-1})				*Est t dm ha^{-1}	Net assimilation (t dm ha^{-1} $period^{-1}$)	Cumulative net assimilation (t dm ha^{-1})
			Foliage	Stalks	Roots	Total			
Plant	1	24,9	0,79	–	0,08	0,87	4,47	3,60	3,60
	2	26,4	4,74	1,21	0,60	6,55	23,61	17,06	20,66
	3	22,6	6,52	3,50	1,00	11,02	25,97	14,95	35,61
	4	16,7	2,84	2,72	0,56	6,12	21,52	15,40	51,01
	5	18,5	5,53	7,01	1,25	13,79	30,90	17,11	68,12
Total						38,35	106,47	68,12	68,12
1st ratoon	1	24,9	3,43	–	0,34	3,77	8,95	5,18	5,18
	2	26,4	7,75	1,95	0,97	10,67	27,64	16,97	22,15
	3	22,6	7,09	4,29	1,14	12,52	25,97	13,45	35,60
	4	16,7	2,56	2,87	0,54	5,97	21,52	15,55	51,15
	5	18,5	4,84	6,95	1,18	12,97	30,90	17,93	69,08
Total						45,90	114,98	69,08	69,08

* From Table 2

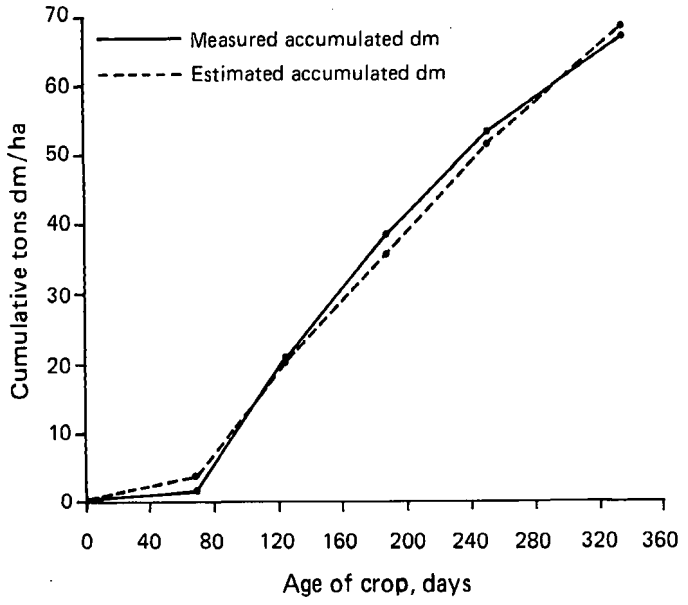

FIGURE 4 Measured and estimated accumulation of dry matter by a plant crop of N14 at Pongola.

The model proposed by Glover[2] is generally shown to provide good agreement with measured data for the plant crop, but the two sets of data for the 1st ratoon crop differ more widely. This can be seen by comparing the final columns of Tables 1 and 3. It is of interest that the model overestimates net assimilation during the first 70 days of the plant crop but underestimates it for the 1st ratoon. This may be due in part to the relative proportions of net assimilate stored in the roots of the two crops. Glover[1] showed that the roots of the previous crop could serve the succeeding ratoon for as long as 8 weeks, whereas a plant crop has to establish its own root system entirely.

The apparent role of respiration in the growth and its effects on the yields of the two crops of N14 is illustrated further in Figure 5. The measured amounts of dry matter production (including a 10% allowance for roots), representing net assimilation, are shown with the amounts of respiration calculated for the two crops during each period of measurement. The sum of these two quantities represents gross assimilation. The final two columns in Figure 5 refer to the whole crops, and the indication is that the plant crop retained more of the gross assimilate as net assimilate because of the lesser amount of R_s incurred in comparison with the 1st ratoon crop.

It is of interest to note that Rostron[5] observed a strong relationship between the initial dry weight of cane and the yield increment during the ensuing 8 weeks. As initial dry weight increased from 0 to 50 t ha^{-1}, the subsequent yield increment decreased from approximately 13 to 0 t ha^{-1}.

The amounts of above-ground dry matter produced by the two crops were estimated from the yields obtained on four 2,44 m lengths of cane row from each crop. Table 1 shows the average above-ground yields of the plant and 1st ratoon crops after 334 days to have been 60,8 and 57,3 t dm ha^{-1} respectively. The standard deviations of the estimates of yield indicated that the mean yields of the two crops were not significantly different. The results can be compared with those obtained on the farm weighbridge when the crops from the whole fields were harvested. The yields of green cane were:

	tc ha^{-1}
Plant cane, west of lysimeter field	159
Plant cane, lysimeter field	162
1st ratoon, east of lysimeter field	164

The amounts of dry matter produced above-ground by plant crops of N14 and NCo376 have been expressed in energy terms (cal cm^{-2} d^{-1}) in Table 4, and as a percentage of

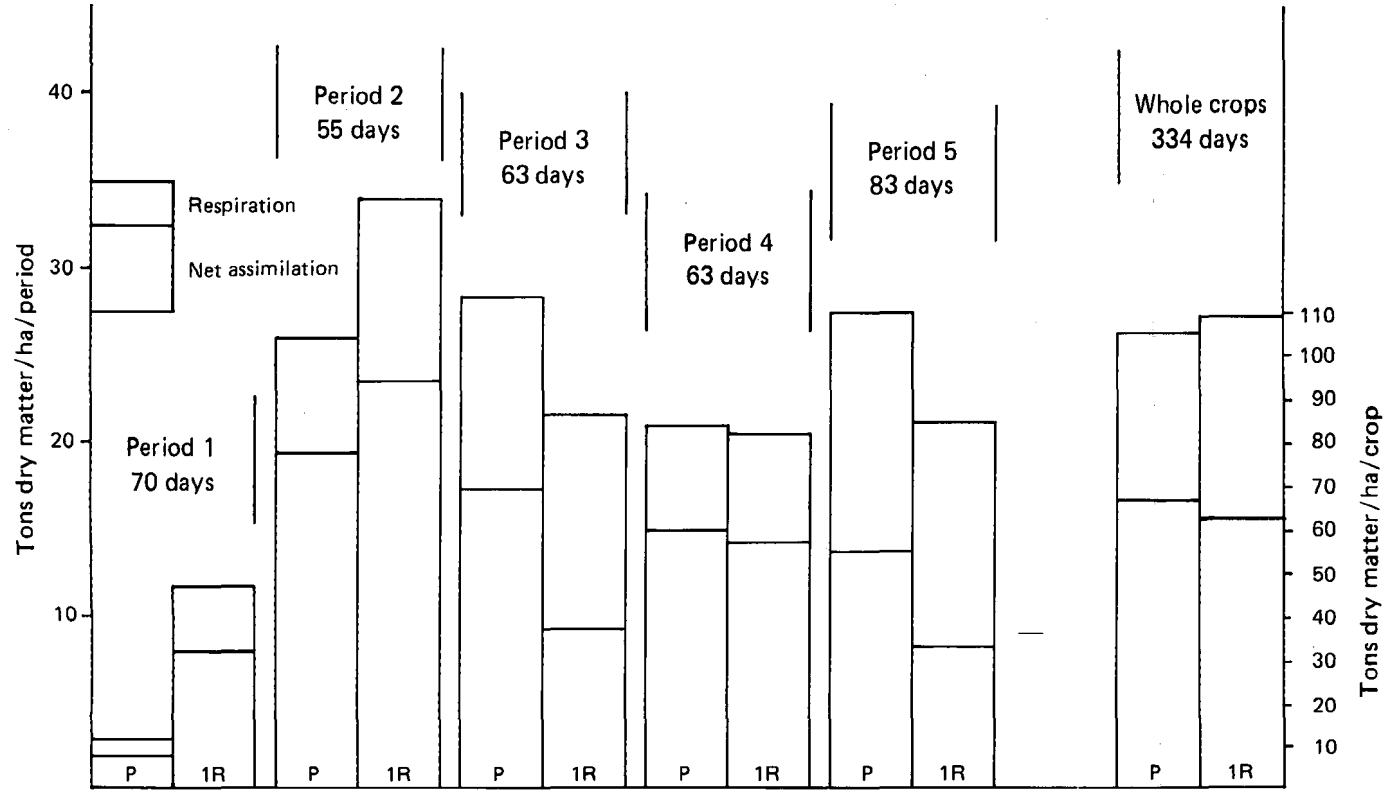

FIGURE 5 Gross dry matter production, respiration and net assimilation for a plant crop and first ratoon crop of N14 grown concurrently during 5 successive periods from 12 November 1986 to 11 October 1987.

total incoming radiation (R_i). N14 appears to have been somewhat more efficient in 1986–87 than was NCo376 in 1967–68 (Thompson[6]). The plant crop of N14 may also have been slightly more efficient than the 1st ratoon crop of N14, ie 1,8% compared with 1,7%. However, in terms of the estimated amounts of gross assimilation the 1st ratoon appears to have been slightly more efficient than the plant crop, ie 3,2% compared with 3,1%. This can be ascribed to the earlier formation of green leaf canopy by the ratoon crop.

Table 4

Photosynthetic efficiency of plant crops of N14 and NCo376, and a 1st ratoon crop of N14

Crop	Period	Above-ground dry matter			Gross assimilation	
		N14		NCo376	N14	
		Cal cm^{-2} d^{-1}	P efficiency (%)	P efficiency (%)	Cal cm^{-2} d^{-1}	P efficiency (%)
Plant	1	0,99	0,2	0,3	1,61	0,3
	2	13,38	2,6	1,8	19,80	3,8
	3	10,45	2,5	2,5	18,84	4,6
	4	9,03	2,6	2,1	14,01	4,1
	5	6,30	1,7	1,9	13,91	3,7
Total		7,65	1,8	1,6	13,24	3,1
1st ratoon	1	4,30	0,8	–	7,00	1,3
	2	16,27	3,1	–	26,05	5,0
	3	5,47	1,3	–	14,37	3,5
	4	8,71	2,5	–	13,56	4,0
	5	3,83	1,0	–	10,77	2,9
Total		7,21	1,7	–	13,70	3,2

The measurements of leaf area made on 19 June 1987 led to the following estimates of LAI:

Plant cane : 6,4
Ratoon cane : 6,5

These values exceed those determined for variety NCo376 at Shakaskraal by Gosnell.[3] The highest values observed for irrigated cane were 5,1 when the crop was 12 months old and 5,6 when it was 16 months old.

Conclusions

A phenomenon frequently observed in experiments is that sugarcane crops which differ markedly in the amount of growth produced above-ground during the early stages of development, show little or no difference in yield at the time of harvesting. This was confirmed in the experiment described here, and at least a partial explanation appears to be the relative amounts of R_s which take place. R_s losses can be estimated from average temperatures and the amounts of accumulated dry matter in different parts of the crop using relationships determined by Glover.[2]

Irrigated crops of NCo376 and N14 at approximately 11 months of age were similar in composition, about 70% of the dry matter being present in the stalk, and the remaining 30% in the foliage and trash.

When photosynthetic efficiency, expressed in terms of the energy content of above-ground dry matter as a percentage of total incoming radiation, is compared, the plant crop of N14 apparently performed slightly better than the 1st ratoon crop. The plant crop of N14 also performed better than a plant crop of NCo376 in this regard. In terms of gross assimilation, however, the 1st ratoon crop of N14 performed better than the plant crop due to its quicker formation of green leaf canopy.

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