THE COMPOSITION OF PLANT AND RATOON CROPS OF VARIETY N14 AT PONGOLA

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Abstract

Material harvested from a growth analysis experiment conducted with sugarcane variety N14 under irrigation at Pongola was used to determine the composition of plant and first ratoon crops that grew concurrently from 12 November 1986 to 12 October 1987. Harvesting took place when the crops were 70, 125, 188, 251 and 334 days old. The amounts of dry matter, fibre, brix, sucrose, glucose, and fructose were determined in the harvested stalks. The proportions of glucose and fructose relative to that of sucrose declined progressively as the crops grew older. The proportions of fibre and brix were reversed as the crop aged from 125 to 334 days. The inorganic constituents of foliage, trash and stalks were also determined at each time of harvesting. The amounts of the major elements contained in the above-ground crops were compared with those of comparable plant crops of variety NCo376 grown at Shakaskraal and Pongola. The most noteworthy features were the high nitrogen content of a crop of NCo376 which was the first crop to be planted on previously uncultivated land on the farm at Pongola, and the high potassium contents of all three crops studied in growth analysis experiments at Pongola.

Introduction

The growth of a plant crop and a first (1st) ratoon crop of variety N14 started on 12 November 1986 in adjacent irrigated fields at Pongola. A lysimeter experiment designed to measure evapotranspiration from the plant crop occupied part of one field. A section of each of the fields 70 m long and 11 cane rows wide was used to conduct a growth analysis experiment on both the plant cane and 1st ratoon cane. The material harvested from the growth analysis experiment provided an opportunity to study the composition of the crops at successive stages of development. Samples from the plots harvested from the lysimeter experiment were also analysed when the crop was 334 days old.

Variety NCo376 had been planted in the same field containing lysimeters on 12 November 1967. A growth analysis experiment was conducted in the adjacent field which was planted at the same time, replicated plots being harvested at approximately monthly intervals. Samples from these plots were also analysed and the results could be compared with those obtained for N14, 19 years later.

Methods

The 70 m of the inner 9 rows, extending from the southern boundary of the field in which 3 weighing lysimeters were located, were pegged at 10 m intervals. The first 10 m were treated as a guard area. Six single row plots, each 10 m long, were thus established in each of 9 rows of N14 plant cane. Subplots, each 2,44 m long, were harvested from within the 10 m plots on 5 occasions. The first harvest took place on 21 January 1987 when the crop was 70 days old. A subplot from each cane row was harvested, providing 9 replications of young cane that comprised almost entirely green foliage.

Subsequently only 4 sub-plots were harvested on each occasion from Rows 3, 5, 7 and 9. The harvested material was divided into green foliage, stalks (including the apical meristem) and trash. Each section was weighed separately. The foliage was chaffed and a sample weighed before drying. After grinding the dry material a subsample was used to determine the contents of nitrogen (N), phosphorus (P), potassium (K), calcuim (Ca), and magnesium (Mg). When the crop matured some flowering occurred. Flowers were separated from the foliage, weighed, dried, and analysed separately.

The stalks were disintegrated to provide a finely divided material from which samples were taken to determine pol, brix and moisture contents. A sample of the juice was used to determine sucrose, fructose and glucose contents by gas chromatography (GC) in the Cane Testing Service laboratory at Mount Edgecombe. The dried stalk material was ground and a subsample used to determine mineral element contents as was done for the foliage. The total amount of trash from each plot was weighed, dried and ground before a subsample was taken to determine the mineral element contents.

The procedures followed for locating and harvesting subplots of the plant crop were followed identically in the adjacent area on a 1st ratoon crop of N14. The same analyses were performed on foliage, flower, stalk, and trash material.

The plant crop received 53 kg N, 18 kg P, and 88 kg 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 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.

Harvesting of plant and 1st ratoon plots was carried out, as described, on the following dates when the ages of the crops were as indicated:

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

When the field was due to be harvested on 12 October 1987, the stalks from each of the subplots were snapped at the natural breaking point. The two parts were weighed, processed and analysed separately. The main part of the stalk represented harvestable cane, and the small apical portion would normally be left in the field as part of the 'tops'. The crops in the 3 weighing lysimeters (each 2,44 m long) were also harvested on this day and treated as were the subplots from the growth analysis experiment. Four additional subplots were located at random in both the plant cane and 1st ratoon fields and harvested on the same day. The cane in the subplots was treated similarly to that from the growth analysis experiment, except that the stalks were not subdivided into sections representing harvestable cane and apical meristem.

Results and discussion

Organic components

The percentages of sucrose, estimated by direct polarisation of the juice extract, in plant crops of NCo376 and N14, and a ratoon crop of N14 (each having started growth on 12 November) are shown in Figure 1. The two plant crops behaved very similarly. The ratoon crop, as predicted because of its quicker development, accumulated sucrose at a faster rate than the plant crops until the final month and a half before harvest. After 330 days of growth, the sucrose contents differed by no more than 0,7 of one percentage unit.

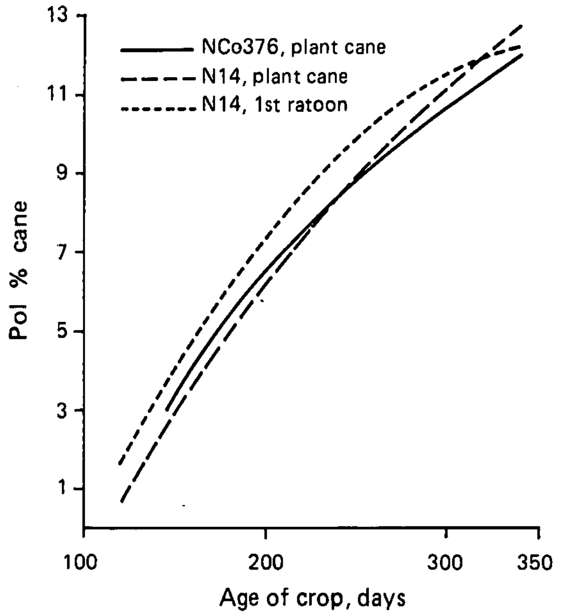

FIGURE 1 Comparison of pol % cane for plant crops of NCo376 (1968) and N14 (1987) and a 1st ratoon crop of N14 (1987).

The patterns of development of the plant and 1st ratoon crops of N14 are illustrated in Table 1. As yield increased with increasing age of the crops, sucrose contents increased progressively, while glucose and fructose contents decreased in terms of percentage composition. Reference to Figure 2 shows that the total amounts of fructose and glucose in the crops also declined rapidly after the crop was 188 days old, while there was concurrently a 2 to 3-fold increase in ts ha^{-1}. Glucose was the predominant reducing sugar present when the crops were 125 and 188 days old, but there were similar amounts of fructose and glucose when they were 251 and 334 days old.

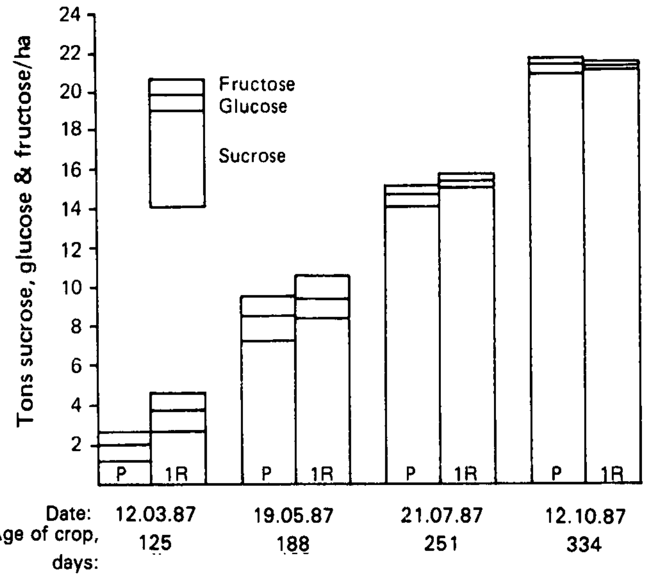

FIGURE 2 Accumulated amounts of sucrose, glucose and fructose ha^{-1} in whole stalks during the development of plant and 1st ratoon crops of N14 at Pongola.

The moisture content of the stalks also declined progressively from about 90% when the crops were 125 days old to about 75% when they were 334 days old. The sucrose content of the 1st ratoon cane in the growth analysis plots was always higher than that in the plant cane, and the percentage purity in the juice extract was also higher until the final harvest date (Table 1).

The dry matter content of sugarcane stalks comprises two parts, fibre and brix. The brix component is made up of sugars and non-sugars. Table 2 lists the percentage composition of the stalks of the two crops on the four occasions when stalks were harvested separately. As the crops progressed from 125 to 334 days old, the proportions of fibre and brix were approximately reversed, the biggest change occurring between 125 and 188 days.

The data for pol % dry matter and sucrose % dry matter illustrate the differences between the direct polarisation and gas chromatographic methods of analysis.

The observed average amounts of fructose, glucose and sucrose shown in Table 2 were used to calculate a 'derived' pol % dry matter in whole cane stalks (Bruijn, J, personal communication). Observed pol and derived pol contents were all within 5% of one another and the differences could have been due to other oligo-saccharides which were not determined.

Table 1

Yield and composition of a plant crop and a 1st ratoon of variety N14 at successive stages of development, and purity of juice

Date	Age of crop (days)	Crop	tc ha^{-1}	Fructose % cane	Glucose % cane	Sucrose % cane	Fibre % cane	Juice purity (%)	dm % cane
17.03.87	125	Plant	82	0,88	1,07	1,34	5,96	30	10,5
		1st ratoon	115	0,76	0,92	2,34	7,17	47	12,2
19.05.87	188	Plant	127	0,85	1,00	5,64	7,74	63	16,6
		1st ratoon	125	0,66	0,84	6,72	8,52	71	18,0
21.07.87	251	Plant	152	0,40	0,37	9,29	9,79	80	21,3
		1st ratoon	144	0,25	0,22	10,40	10,95	83	23,4
12.10.87	334	Plant	167	0,15	0,15	12,50	11,03	87	25,4
		1st ratoon	151	0,11	0,10	13,03	11,80	87	26,8

Table 2
Distribution of dry matter in a plant crop and 1st ratoon of variety N14 on four occasions

Crop	Item (% dm)	Date			
		17.03.87	19.05.87	21.07.87	12.10.87
P	Fibre	56,8	46,5	45,9	43,3
	Brix	43,2	53,5	54,1	56,7
	Pol	9,1	31,7	41,7	47,4
	Fructose	8,4	5,1	1,9	0,6
	Glucose	10,2	6,0	1,7	0,6
	Sucrose	12,8	34,0	43,6	49,1
	Sugars	31,4	45,1	47,2	50,3
	Non-sugar	11,8	8,4	6,9	6,4
1R	Fibre	59,0	46,1	46,7	44,1
	Brix	41,0	53,9	53,3	55,9
	Pol	16,6	36,1	42,4	46,2
	Fructose	6,2	3,7	1,1	0,4
	Glucose	7,5	4,7	0,9	0,4
	Sucrose	19,3	37,3	44,4	48,7
	Sugars	33,0	45,7	46,4	49,5
	Non-sugar	7,8	8,2	6,9	6,4

The ideal point at which cane stalks should be broken so that the maximum amount of recoverable sucrose can be delivered to the mill is often referred to as the 'natural breaking point'. The data given in Table 3 show the proportions of the various crop components that occurred in the two parts of the stalks from the plant and 1st ratoon crops in the growth analysis plots. About 99% of the total dry matter in stalks was contained in the 'harvestable cane' from both crops. There were similarly high proportions of fibre, brix and sucrose in the harvestable cane, but the short apical stem sections contained more than 25% of the reducing sugars in the plant crop, and more than 15% in the ratoon crop. The purity of the extract from the stalk apexes was about 20% for both crops.

Inorganic components

Table 4 shows the amounts of major nutrients contained in the above-ground parts of three plant crops. These were rainfed NCo376 at Shakaskraal in 1963 (SK) (Bishop[1]), irrigated NCo376 at Pongola in 1968 (PG1) (Thompson[4]), and irrigated N14 at Pongola in 1987 (PG2). In all instances the crops had accumulated most of their N contents in March when the NCo376 at Shakaskraal was 5 months old and the other two crops were 4 months old. For K this was also the case 2 months later in May. The results indicate that about 70% of the N in the crop at the time of harvest is contained in the crop when it is 4 months old, and about 80% of the K is present when the crop is 6 months old. It is of interest to note that Ca and Mg tended to accumulate in the crops until the time of harvest at 11 or 12 months of age. Bishop[1] showed that P, Ca and Mg continued to accumulate in rainfed NCo376 until the crop was 22 months old.

Table 3
Distribution of components of cane stalks of plant and 1st ratoon crops of variety N14 between top (stalk apex) and bottom (harvestable cane) when the crops were 334 days old

Crop	Part of stalk	t ha^{-1}						
		Total dm	Fibre	Brix	Fructose	Glucose	Sucrose	Total sugars
P	Top	0,5	0,2	0,3	0,05	0,06	0,07	0,18
	Bottom	41,9	18,2	23,8	0,20	0,20	20,79	21,19
	Total	42,4	18,4	24,1	0,25	0,26	20,86	21,37
1R	Top	0,3	0,2	0,2	0,02	0,02	0,04	0,08
	Bottom	42,9	18,9	24,0	0,15	0,14	21,02	21,31
	Total	43,2	19,1	24,2	0,17	0,16	21,06	21,39

A major difference between NCo376 at Pongola in 1968 and N14 on the same site in 1987 was the amount of N accumulated (Table 4). Presumably this occurred because the field was virgin land in 1966 and N-mineralisation was exceptionally rapid when the soil was first disturbed.

A second unusual phenomenon was the amount of K taken up by both crops at Pongola, 19 years apart. The 790 kg K taken up ha^{-1} in 1967–68 might have been due to an accumulation of K in the soil during hundreds of years when the land was uncultivated. The histories of the lysimeter field (318) and the adjacent field where the 1st ratoon of N14 was grown (319) during the 21 years since the land was first disturbed for cultivation are as follows:

	Field 318	Field 319
Years under:		
cane	8	9
cotton	9	8
Eragrostis curvula	1	1
potatoes	1	1
fallow (weeds)	2	2

The average application of K fertilizer was approximately 30 kg ha^{-1} a^{-1} during this period. The crop of N14 planted in 1986 received a total of 152 kg K ha^{-1} and the 1st ratoon

Table 4
Amounts of major nutrients ha^{-1} contained in the above-ground parts of plant crops of NCo376 at Shakaskraal (SK), Pongola (PG1), and a plant crop of N14 at Pongola (PG2)

Nutrient	kg ha^{-1}											
	March			May			July			October		
	SK	PG1	PG2	SK	PG1	PG2	SK	PG1	PG2	SK	PG1	PG2
N	136	156	118	148	219	114	152	224	151	168	276	132
P	14	16	16	16	22	24	15	23	22	18	29	27
K	198	290	425	216	648	530	181	651	638	214	790	652
Ca	29	41	39	47	77	54	31	65	78	46	74	80
Mg	36	26	33	44	53	54	45	47	65	55	64	71

crop received 130 kg K ha^{-1}. Stewart[3] reported that the normal K content of a sugarcane crop is about 1,5 kg K t^{-1} of harvestable cane. The comparable data are:

Type of sugarcane crop	kg K removed ha^{-1}
Average crop	250
Plant crop N14, 1987	397
1st ratoon crop N14, 1987	472
Plant crop, lysimeters, 1987	206

It appears that the shallower profile in the lysimeters (1 m of soil) provided much less K for the crop than did the surrounding land due not only to the shallower depth, but possibly also more severe K depletion during the past 19 years. On a nearby site it has been shown that root activity of sugarcane extends to a depth in excess of 2 m (Thompson and Boyce[6]). In a long term N, P and K trial on another nearby site, Moberly[2] observed that significant responses to K fertilizer were observed after sugarcane had been harvested on 9 occasions, the response reaching a maximum of 2 ts ha^{-1} in the 9th ratoon crop. During the first 11 years of the trial, which was harvested annually, available K in the surface soil decreased from 295 to 97 ppm in control plots which received no K fertilizer and to 116 ppm in plots which received 110 kg K ha^{-1} for each crop. The implications are that continuous cropping with sugarcane drains the reserves of K in the soil more severely than does a succession of other crops, mainly cotton, interspersed with sugarcane.

A soil sample taken from lysimeter 1 before planting in September 1986 contained 260 kg available K ha^{-1}, which is below the threshold value of 340 kg ha^{-1} for soils with more than 30% clay. A soil sample from the surrounding area contained 512 kg available K ha^{-1}. Leaf samples taken on 18 January 1987 from the cane surrounding lysimeters 1, 2 and 3 contained an average of 1,45 K % dry matter, also well above the threshold value of 1,05%. A sample from the adjacent field of 1st ratoon contained 1,57% K. Samples taken subsequently on 18 March 1987 contained 1,60% K and 1,26% K for the plant and 1st ratoon fields respectively.

The mean yields of total above-ground dry matter from the lysimeters was 54,3 t ha^{-1}, and from the total of 8 other plots in the field 56,8 t ha^{-1} when the crops were 334 days old.

In Table 5 can be seen the distribution of major nutrients in different parts of the plant and 1st ratoon crops of N14 on successive harvesting dates. After 334 days about 70% of the P and K in the above-ground parts of the crops was contained in the stalks, whereas only about 30% of the N, 25% of the Ca, and 40% of the Mg occurred in the stalks. While N, particularly, was concentrated in the foliage, Ca tended to accumulate in the trash.

Flowering was most profuse in the plant crop of N14 in the lysimeters, 42% of the harvestable stalks having inflorescences. The mineral composition of the flowers is compared in Table 6 with the composition of the apical meristem and the foliage of the stalks harvested after 334 days from the lysimeters. There were no flowers on 58% of the stalks, and the remainder had inflorescences which varied from unemerged to mainly senescent flowers and were comparatively dry. The main differences in composition of the flowers compared with that of adjacent tissues are the low amounts of Ca and Mg % dry matter. N and P contents of the flowers were similar to those in the apical meristem while K content was less than that in the meristem but more than that in the foliage.

Table 5

Amounts of major nutrients in different parts of a plant and 1st ratoon crop of variety N14 on 5 successive occasions

Date and age in days	Crop	Part	kg ha^{-1}				
			N	P	K	Ca	Mg
21.01.87 (70)	P	Foliage	24	2,9	48	5	4
	1R	Foliage	71	10,7	190	20	18
17.03.87 (125)	P	Foliage	81	9,1	226	24	19
		Stalk	35	6,2	192	12	12
		Trash	2	0,2	7	3	2
		Total	118	15,5	425	39	33
	1R	Foliage	88	11,5	253	34	25
		Stalk	42	12,7	285	18	17
		Trash	8	0,6	24	8	6
		Total	138	24,9	562	60	48
19.05.87 (188)	P	Foliage	73	9,1	180	23	22
		Stalk	32	13,8	311	15	21
		Trash	9	1,4	39	16	11
		Total	114	24,3	530	54	54
	1R	Foliage	68	9,1	165	24	20
		Stalk	25	16,5	360	13	18
		Trash	9	1,6	39	14	12
		Total	102	27,2	564	51	50
21.07.87 (251)	P	Foliage	82	9,4	208	31	26
		Stalk	53	11,4	400	27	25
		Trash	16	1,2	30	20	14
		Total	151	22,0	638	78	65
	1R	Foliage	64	7,1	143	24	22
		Stalk	48	14,7	451	25	23
		Trash	20	1,6	27	18	14
		Total	132	23,4	621	67	59
12.10.87 (334)	P	Foliage	64	8,0	202	25	23
		Stalk	45	17,5	421	21	30
		Trash	23	1,7	29	34	18
		Total	132	27,2	652	80	71
	1R	Foliage	53	7,6	149	27	18
		Stalk	31	23,9	486	22	26
		Trash	24	0,8	23	35	16
		Total	108	32,3	658	84	60

Table 6

The nutrient contents of foliage, apical meristem and inflorescences of plant cane of variety N14 harvested from the lysimeters

Part of crop	% dry matter				
	N	P	K	Ca	Mg
Foliage	0,66	0,08	1,12	0,36	0,28
Apical meristem	0,68	0,13	2,99	0,28	0,41
Inflorescences	0,64	0,15	1,53	0,14	0,13

Conclusions

Sucrose accumulates faster in a ratoon crop than in a plant crop, but at 11 months of age the sucrose contents of plant crops of NCo376 and N14, and a ratoon crop of N14 were similar. Progression towards this similarity might be explained at least in part by the relative amounts of respiration occurring in the different crops (Thompson[5]).

Rapid mineralisation of N in a virgin soil after it is first disturbed for cropping is the likely cause of the high N content of a plant crop observed at Pongola. Luxury consumption of K has been demonstrated and there is evidence that the depth of soil from which K can be exploited by cane roots is important. Sugarcane accumulates N and K rapidly during the early months of crop development but P, Ca and Mg accumulate fairly continuously over the full duration of the crop.

The composition of sugarcane flowers differs from that of the apical meristem to which they are attached, mainly in terms of K, Ca and Mg contents. The concentrations of these three elements in dry matter are about half as great in the flowers as they are in the apical meristems.

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