# THE EFFECTS OF AGE AND TIME OF HARVEST ON THE PRODUCTIVITY OF IRRIGATED SUGARCANE

By H. ROSTRON

*South African Sugar Association Experiment Station*

**Abstract**

Data are presented for eight irrigated, well fertilised sugarcane crops of variety NCo 376, planted and harvested at different times of the year and subdivided in the first ratoon crop for harvesting at ages ranging from 32 to 72 weeks. The growth of the ratoon crops declined after 40 weeks of age and the rate of decline depended on the time of year at which the crops began to grow. The older the ratoon crop at harvest, the higher the concentration of estimated recoverable sugar (ers %) in the cane. The range of ers % amongst crops of different ages was least in crops harvested in August. Ers % was low in crops of all ages in February and March. The maximum yield of estimated recoverable sugar per hectare per month (ters/ha/month) was obtained at 64 weeks of age for crops ratooned in January or February. There was a gradual change as crops began to grow later in the year and the maximum ters/ha/month of crops ratooned between September and December was obtained at 40 weeks.

Early lodging and the production of non-millable bull shoots in October and November plant crops and a December ratoon crop were associated with low yields of both cane and sugar. January and February ratoon crops, which grew more slowly, did not lodge as soon and gave the highest yields of 184 - 194 tc/ha and 23 ters/ha. It is concluded that crops that begin to lodge at the beginning of summer should not be allowed to carry over for harvest in the following season.

## Introduction

In South Africa, sugarcane is harvested at ages ranging from 10 to 17 months of age in the northern irrigated areas and from 16 to 30 months of age in the colder Midlands area. There is, however, little information on the optimum age at harvest in order to maximise sugar production, either in different areas, or for different growing cycles within any one area.

Under rainfed conditions, Pearson[1] found that over a four year period cutting at 12-monthly intervals gave higher yields of sugar than did cutting at 16, 20 or 24 monthly intervals. This was in part due to the 16 and 20 month crops ratooning at less favourable times of year than the 12 month crops. It is known, however, that the productivity of both irrigated and rainfed sugarcane declines with increasing age (Gosnell[2], Borden and Denison[3]). Moberly[4], under irrigated conditions, found that sugarcane in an eighteen month cycle alternating between May and November, gave higher yields of recoverable sugar over a three year period than did the average of 12 month crops which ratooned in both May and November. This was largely due to a higher percentage of recoverable sugar in the older crops.

There have been few attempts to measure the effect of age alone on the productivity of field-grown sugarcane. In most experiments, treatments have been restricted to selected times of the year and the effects of age have been confounded with those of changing weather conditions. Although growth generally declines with increasing age, under some conditions growth in the second summer is equal to that in the first (Du Toit[5]), and it has been suggested that size rather than the age of a crop determines its ability to respond to favourable weather conditions (Moberly[4], Rostron[6]).

To separate the effects of age and weather on the growth and productivity of sugarcane, an irrigated experiment was established on a rich, heavily fertilized soil at the Pongola sub-station of the South African Sugar Association. This paper contains details of yields and stalk characteristics of plant crops cut throughout the year, and of ratoon crops of various ages cut at different times of the year.

## Methods

Eight plantings of variety NCo 376, replicated six times, were established at seven-week intervals between 8 November 1967 and 16 October 1968 on a soil of the Makatini series. The main part of the experiment was conducted on the first ratoon, in order that the crop would be as uniform as possible. Plant crop yields were measured on plots which were 42 m². In order to increase the interval between times of harvest of the first ratoon crops from seven to eight weeks, the age of successive plant crops at the time of harvest was increased by one week, and ages at harvest therefore ranged from 58 to 65 weeks. Plant crops were not burnt but all trash was removed from the plots to improve the uniformity of germination of the ratoon crops.

Each main plot (planting) of 404 m² was divided in the ratoon crop into six sub-plots comprising 3 rows, each 5,5 m long and spaced 1,5 m apart (25 m²). Sub-plots were harvested at eight weekly intervals from 32 to 72 weeks of age. The number of shoots in two rows of 5,5 m length per plot were counted at various times until the crop was 32 weeks old. Stalk height from the top of a fixed peg to the uppermost visible dewlap (TVD) was measured on 10 stalks chosen at random within each plot.

Cane yield was recorded at the time of harvest, and sucrose and dry matter contents of the cane were determined on samples of 10 stalks per plot. Topping was done by hand at the base of the sheath attached to the sixth leaf (leaf number one being that which was more than half unfurled) when the crops were small. When the top became only a small proportion of the stalk, topping was done with a cane knife. The length of the stalk and its diameter at the top, middle and bottom were measured on a 5% sample of stalks from each plot.

The plant crops were fertilized with a total of 224 Kg N, 93 Kg P and 56 Kg K per hectare, and the ratoon crops were topdressed with 224 Kg/ha N to ensure that sufficient nutrients were available for maximum growth. To check on the nutrient status of the ratoon crops, samples of the third leaf from plantings four to eight were analysed at various ages. Irrigation, which was by overhead sprinkler, was more than adequate to meet the water requirements of the crop and was continued up to the time of harvest. The moisture status of the ratoon crops was checked on 3-6 sheath samples taken from plantings six to eight.

## Results

*Plant crops*

Cane yields of the plant crops varied with the cropping cycle (Fig. 1). Planting in November and harvesting in December produced the lowest yield of 133 tc/ha and the February planting gave the highest yield of 244 tc/ha. The October and November plantings were the only ones to produce non-millable bull shoots, which weighed 15,9 t/ha and 5,9 t/ha respectively.

The percentage estimated recoverable sugar (ers %) followed the expected seasonal pattern, with a gradual change from a minimum value of 5,7% for a crop harvested in February to a maximum of 11,8% for a crop harvested in November. For crops harvested between February and June fluctuations in sugar yield per hectare resembled fluctuations in cane yield, but after June ers % became the dominating factor (Fig. 1). The maximum sugar yield of 21 ters/ha was obtained from a crop which was planted in August and harvested in November when it was 64 weeks old. The lowest yield of 12 ters/ha was from a December crop that was harvested in February when it was 59 weeks old. Measurements of harvested stalks did not correlate well with cane yield, but the highest yielding crops, which were those planted between December and April, had high populations of thick stalks.

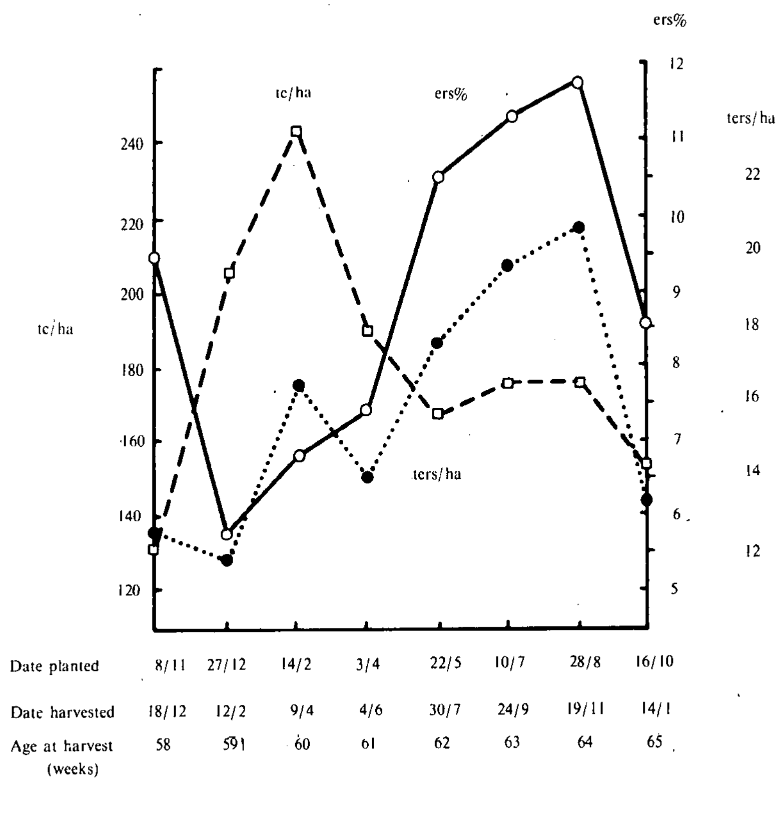


Figure 1. Yield data for crops planted and harvested at different times of the year.

*Growth of the ratoon crops*

Shoot populations and the rate of shoot elongation during the first six months of growth varied from crop to crop. Crops that began to grow between December and February, when total radiation and temperatures were high (Fig. 2), exhibited early peak populations of 480-500 000 shoots per hectare at 1-2 months of age (Fig. 3). The population of the December crop then fell sharply as the surviving shoots elongated rapidly (Fig. 4). In the February crop the population declined gradually and the rate of elongation was much slower than in the December crop. Crops that ratooned in April and June elongated slowly and reached peak shoot populations at about five months of age. After June, there was a gradual change in the characteristics of the crops as the weather became warmer. Rates of shoot elongation increased, peak populations occurred earlier and the rate of population decline became steeper. The high, late peak population of the crop ratooned in April was not confirmed by check counts done on second ratoon crops that also began to grow in April.

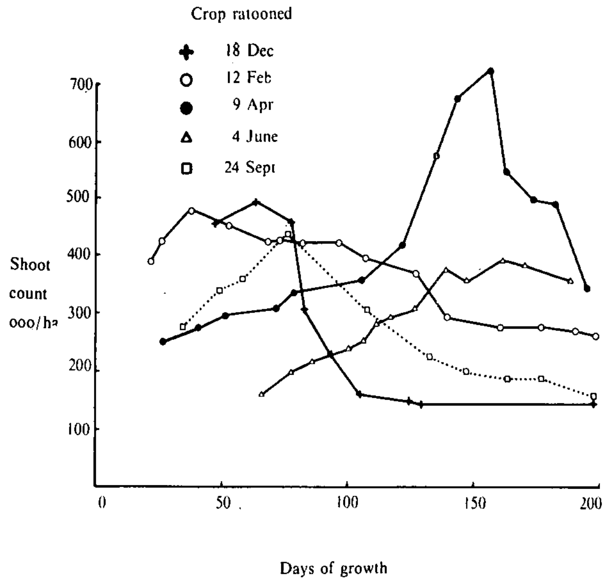


Figure 3. Changes with time in the shoot population of five ratoon crops growing at different times of the year.

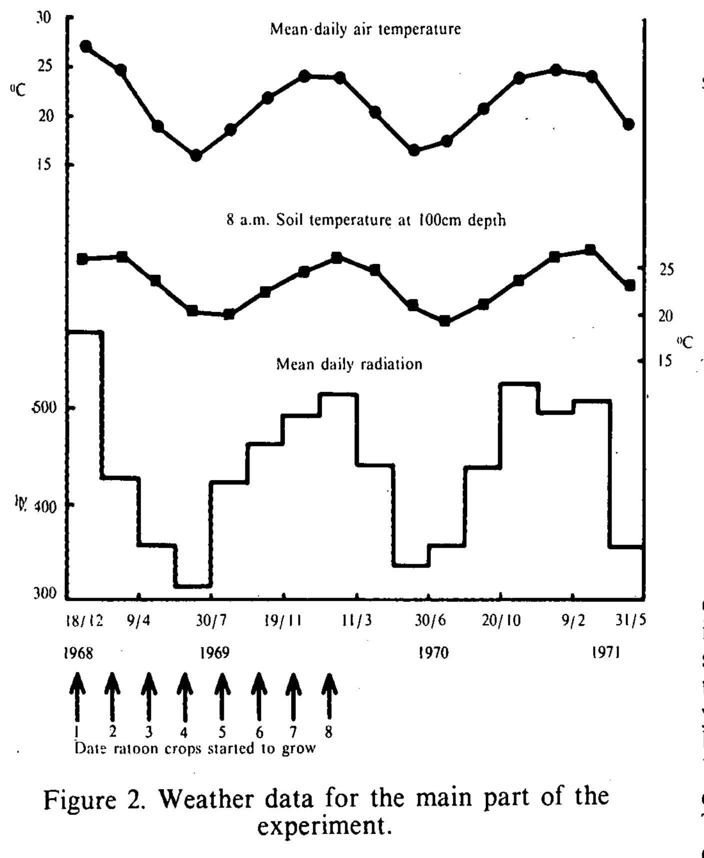


Figure 2. Weather data for the main part of the experiment.

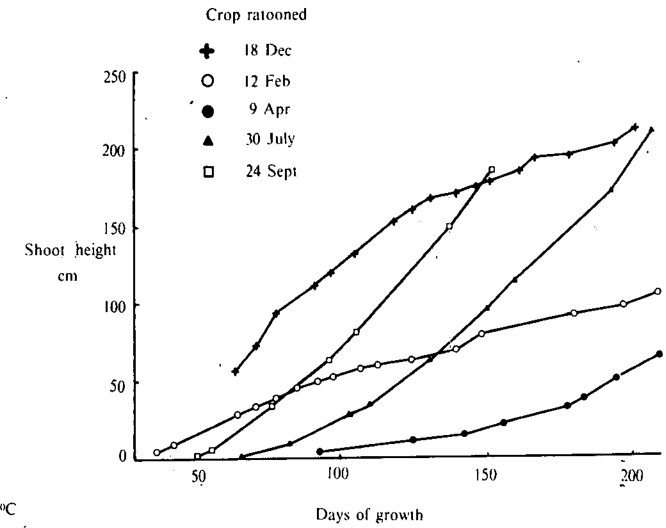


Figure 4. Height to the TVD of shoots of ratoon crops growing at different times of the year.

The patterns of growth for six of the ratoon crops between 32 and 72 weeks of age are shown in Fig. 5. They have been presented in terms of stalk dry matter because the moisture content of the cane varied with both age and the time of year at which the crop was harvested. Crops that began to grow between April and September behaved similarly and data for June and August crops have therefore been omitted from Fig. 5. The grouping and the similarity of the growth curves of these winter crops contrasted with the large differences amongst crops that began to grow during summer.

Crops starting to grow in December 1968 and November 1969 produced high stalk yields at 32 weeks of age (Fig. 5) and the growth rate fell rapidly with increasing age. In the December crop, this decline in growth was associated with early lodging and the production of non-millable bull shoots. Crops starting to grow in February 1969 and January 1970 had low yields at 32 weeks of age and yield then increased almost linearly up to 64 weeks.

The population of harvested stalks fell with increasing age (Table I), particularly between 32 and 52 weeks of age for crops that began to grow between December and February. Stalk length continued to increase at successive harvests (Table I), although crops that began to grow between April and July made less growth than other crops between 52 and 72 weeks of age. The crop that started to grow in December had the thinnest stalks at all times of harvest.

The decline in the rate of growth of all crops as they became older did not appear to be related to either the nutrient or the moisture status of the crop. Sheath moisture contents of the later crops were similar to the 80-83% regarded by Clements, Shigeura and Akamine[7] to be satisfactory for the growth of crops more than one year old. Changes in nutrient concentration of the third leaf of samples from planting eight (Table II) did not indicate a shortage of nutrients as the crop became older, and corresponding values for other crops sampled were similar to, or higher than those of this planting.

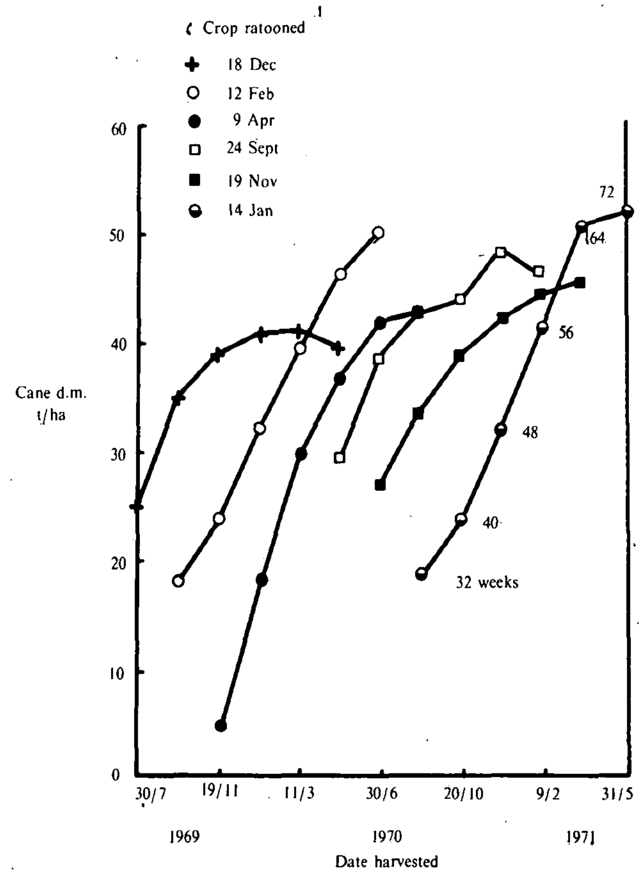


Figure 5. The stalk dry matter yield of six ratoon crops, harvested at different times of the year at ages ranging from 32 to 72 weeks.

**TABLE I**

**Stalk populations and the harvested stalk dimensions of ratoon crops that began to grow at different times of the year**

| Age of crop | Date of previous harvest 1968 18/12 | 1969 12/2 | 1969 9/4 | 1969 4/6 | 1969 30/7 | 1969 24/9 | 1969 19/11 | 1970 14/1 |
|---|---|---|---|---|---|---|---|---|
| Stalk population (000/ha) | | | | | | | | |
| 32 weeks | 181 | 188 | 139 | 151 | 139 | 144 | 144 | 171 |
| 52 weeks* | 154 | 150 | 134 | 130 | 131 | 139 | 144 | 146 |
| 72 weeks | 150 | 145 | 130 | 134 | 118 | 128 | 127 | 129 |
| Stalk length (cm) | | | | | | | | |
| 32 weeks | 176 | 92 | 62 | 106 | 198 | 225 | 202 | 131 |
| 52 weeks* | 236 | 208 | 218 | 256 | 268 | 267 | 243 | 211 |
| 72 weeks | 250 | 259 | 243 | 259 | 276 | 295 | 294 | 336 |
| Mean stalk diameter (mm) | | | | | | | | |
| 32 weeks | 19,4 | 22,3 | 27,6 | 24,8 | 23,6 | 23,8 | 22,4 | 21,6 |
| 52 weeks* | 21,7 | 24,2 | 24,8 | 24,4 | 24,4 | 23,1 | 22,5 | 23,4 |
| 72 weeks | 22,4 | 24,4 | 24,8 | 24,2 | 24,1 | 23,6 | 23,1 | 23,9 |

* Mean of 48 and 56 week harvests

**TABLE II**

**Percentage composition of the laminae of the third leaves of a ratoon crop that began to grow on 14 January 1970**

| Element | Age in weeks 16 | 24 | 32 | 40 | 48 | 56 | 64 | 72 |
|---|---|---|---|---|---|---|---|---|
| Nitrogen | 2,44 | 2,10 | 1,96 | 1,69 | 1,65 | 1,66 | 1,49 | 1,59 |
| Phosphorus | 0,24 | 0,23 | 0,20 | 0,19 | 0,21 | 0,21 | 0,21 | 0,22 |
| Potassium | 1,86 | 1,90 | 1,76 | 1,60 | 1,72 | 1,88 | 1,82 | 1,68 |
| Calcium | 0,28 | 0,29 | 0,28 | 0,24 | 0,19 | 0,20 | 0,16 | 0,20 |
| Magnesium | 0,26 | 0,24 | 0,20 | 0,19 | 0,23 | 0,20 | 0,14 | 0,14 |

*Yields of cane and sugar in the ratoon crops*

Crops that began to grow between June and September had high yields of 162-166 tons of cane per hectare (tc/ha) at 52 weeks of age (Table III) but there was little further increase during the next 20 weeks. Crops starting in January and February had low initial cane yields but had very high yields of 184-194 tc/ha at 64-72 weeks of age. The crop starting in December, which lodged at an early age in September, had a low maximum yield of 145 tc/ha and produced 50 t/ha of bullshoots at 72 weeks. All crops lodged badly (Table III) and there was little or no increase in cane yield after lodging occurred.

Changes in purity and sucrose percent cane followed similar patterns throughout the experiment and the typical pattern is illustrated by changes in estimated recoverable sugar (ers %) in Fig. 6. The younger the age at harvest, the lower the ers % at all times of the year, and in general, the greater the response to changes in weather conditions. There was a pronounced peak in the ers % of crops harvested at less than 56 weeks of age but the range in ers % of 56-72 week old cane was less than 1,4% between May and March the following year. Purity was generally low (Table IV) and changes in ers % (and purity) of young crops were associated with natural increases in dry matter percentage of the cane (Fig. 7).

**TABLE III**

**Cane yields (tc/ha) at various ages of ratoon crops growing at different times of the year, and details of when the crops became badly lodged**

| | Date of previous harvest | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1968 | 1969 | | | | | | 1970 |
| | ** 18/12 | 12/2 | 9/4 | 4/6 | 30/7 | 24/9 | 19/11 | 14/1 |
| tc/ha, 32 weeks | 110 | 80 | 32 | 74 | 123 | 140 | 122 | 82 |
| tc/ha, 52 weeks* | 137 | 146 | 150 | 166 | 166 | 162 | 148 | 146 |
| Maximum tc/ha | 145 | 184 | 160 | 171 | 168 | 174 | 171 | 194 |
| Age (weeks) | 56 | 72 | 64 | 56 | 64 | 64 | 72 | 64 |
| Age at lodging (weeks) | 40 | 56 | 48 | 56 | 56 | 56 | 52 | 56 |
| Time of year | Sept. | Mar. | Mar. | June | Aug. | Oct. | Nov. | Feb. |
| % tc/ha increase | | | | | | | | |

*Mean of 48 and 56 week harvests.
**This crop produced 21 t/ha bull shoots at 64 weeks and 50 t/ha at 72 weeks.

**TABLE IV**

**Juice purity of ratoon crops, which grew at different times of the year and were harvested at various ages**

| | Date of previous harvest | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Age at harvest | 1968 | 1969 | | | | | | 1970 |
| (weeks) | 18/12 | 12/2 | 9/4 | 4/6 | 30/7 | 24/9 | 19/11 | 14/1 |
| 32 | 78 | 72 | 31 | 38 | 52 | 76 | 75 | 68 |
| 52* | 84 | 79 | 76 | 80 | 84 | 82 | 81 | 83 |
| 64 | 84 | 91 | 86 | 85 | 82 | 86 | 87 | 77 |
| 72 | 89 | 88 | 87 | 82 | 85 | 88 | 74 | 88 |

*Mean of 48 and 56 week harvests

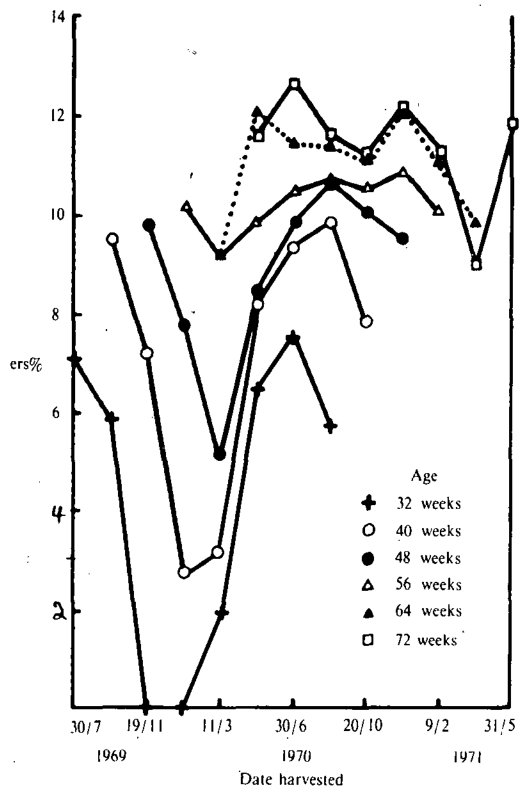


Figure 6. The effect of ers % cane of harvesting cane of different ages at various times of the year.

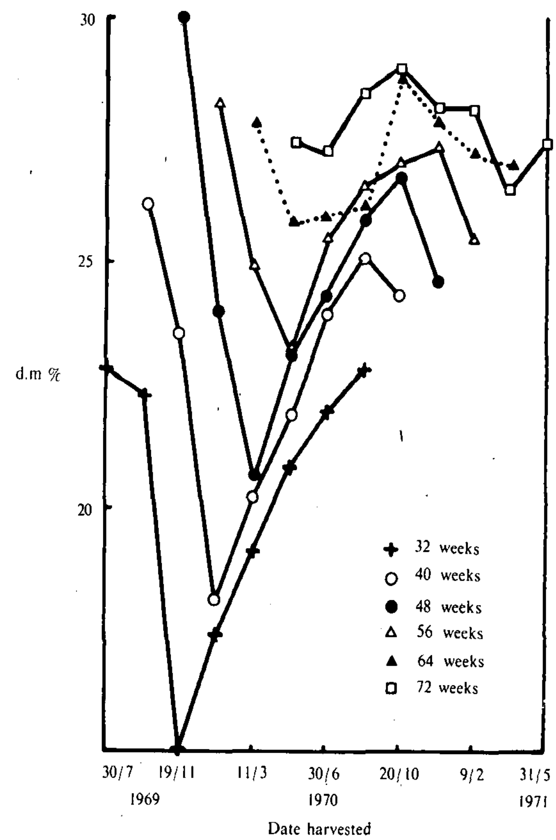


Figure 7. The effect on the percentage cane dry matter of harvesting cane of different ages at various times of the year

Sugar production per hectare (ters/ha) increased with age and maximum yields were obtained at either 64 or 72 weeks of age for all crops (Table V). The pattern of sugar accumulation varied with the time of year of the previous harvest. Crops that began to grow in July and September had high yields at 48 weeks of age whilst crops that began to grow in January and February had a low yield of ters/ha at 48 weeks but gave the highest yields in the experiment of 23 ters/ha at 72 weeks of age. The largest increase in ters/ha within any one eight week period occurred between March and May for crops of most ages.

Sugar production per hectare per unit time (ters/ha/month) is presented in Table VI. Crops starting at all times of the year, except April, had similar maximum rates of productivity, ranging from 1,3 to 1,6 ters/ha/month. The age at which the maximum productivity of each crop occurred changed gradually from 64 weeks for crops that started to grow in January and February to 40 weeks for crops that started between September and December.

**TABLE V**

**Estimated yields of recoverable sugar per hectare (ters/ha) of crops of different ages harvested at various times of the year.**

| Harvest date | Date of previous harvest | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1968 | 1969 | | | | | | 1970 |
| | 18/12 | 12/2 | 9/4 | 4/6 | 30/7 | 24/9 | 19/11 | 14/1 |
| 1969 | | | | | | | | |
| 30/7 | 7,9 (32)* | | | | | | | |
| 24/9 | 12,8 (40) | 4,7 (32) | | | | | | |
| 19/11 | 12,8 (48) | 7,4 (40) | — (32) | | | | | |
| 1970 | | | | | | | | |
| 14/1 | 14,9 (56) | 10,6 (48) | 2,7 (40) | — (32) | | | | |
| 11/3 | 12,6 (64) | 14,6 (56) | 7,3 (48) | 4,0 (40) | 2,5 (32) | | | |
| 5/5 | 16,6 (72) | 21,6 (64) | 15,6 (56) | 13,6 (48) | 12,8 (40) | 9,2 (32) | | |
| 30/6 | | 23,3 (72) | 18,4 (64) | 18,0 (56) | 16,4 (48) | 15,1 (40) | 9,3 (32) | |
| 26/8 | | | 17,4 (72) | 18,8 (64) | 18,0 (56) | 17,5 (48) | 13,1 (40) | 4,7 (32) |
| 20/10 | | | | 18,4 (72) | 18,5 (64) | 16,8 (56) | 14,5 (48) | 8,2 (40) |
| 15/12 | | | | | 19,2 (72) | 21,2 (64) | 16,7 (56) | 12,4 (48) |
| 1971 | | | | | | | | |
| 9/2 | | | | | | 18,7 (72) | 17,9 (64) | 16,4 (56) |
| 6/4 | | | | | | | 15,6 (72) | 20,0 (64) |
| 31/5 | | | | | | | | 22,6 (72) |

( )* Age in weeks

**Discussion**

The results of this experiment confirmed that under good growing conditions, with no evidence of nutrient deficiency or moisture stress, the rate of stalk dry matter production in ratoon crops declined after 40 weeks. This decline in growth occurred later in crops that had low yields at 32 weeks of age than in crops that grew fast initially. Ratoon crops that began to grow between April and November had similar patterns of growth and similar maximum yields of cane, despite large differences in shoot population and shoot elongation during early growth. In contrast to this, ratoon crops that began to grow in December and either January, or February had very different patterns of growth and maximum cane yields.

The crop that ratooned in December had very low yields of both cane and sugar because it lodged at 40 weeks of age in September, and further growth was in the form of non-millable bull shoots. This early lodging appeared to be related to the rapid rate of shoot elongation and the production of thin stalks, compared with the February crop that ratooned only eight weeks late, and the January crop that ratooned 13 months later. These crops, which had slower elongation rates and thicker stalks, lodged at 56 weeks of age and produced high yields of cane and sugar. It is possible that lodging was the cause of the decline in growth with increasing age in all the ratoon crops. There was, however, no apparent difference in the severity of lodging between the crops ratooned in January and

**TABLE VI**

**Sugar production per unit area per unit time (ters/ha/month) for crops of different ages harvested at various times of the year**

| Harvest date | Date of previous harvest | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1968 | 1969 | | | | | | 1970 |
| | 18/12 | 12/2 | 9/4 | 4/6 | 30/7 | 24/9 | 19/11 | 14/1 |
| 1969 | | | | | | | | |
| 30/7 | 1,1 (32)* | | | | | | | |
| 24/9 | 1,4 (40) | 0,6 (32) | | | | | | |
| 19/11 | 1,2 (48) | 0,8 (40) | — (32) | | | | | |
| 1970 | | | | | | | | |
| 14/1 | 1,2 (56) | 0,9 (48) | 0,3 (40) | — (32) | | | | |
| 11/3 | 0,9 (64) | 1,2 (56) | 0,6 (48) | 0,4 (40) | 0,3 (32) | | | |
| 5/5 | 1,0 (72) | 1,5 (64) | 1,2 (56) | 1,2 (48) | 1,4 (40) | 1,2 (32) | | |
| 30/6 | | 1,4 (72) | 1,2 (64) | 1,4 (56) | 1,5 (48) | 1,6 (40) | 1,2 (32) | |
| 26/8 | | | 1,0 (72) | 1,2 (64) | 1,4 (56) | 1,5 (48) | 1,4 (40) | 0,6 (32) |
| 20/10 | | | | 1,1 (72) | 1,2 (64) | 1,3 (56) | 1,3 (48) | 0,9 (40) |
| 15/12 | | | | | 1,2 (72) | 1,4 (64) | 1,3 (56) | 1,1 (48) |
| 1971 | | | | | | | | |
| 9/2 | | | | | | 1,1 (72) | 1,2 (64) | 1,2 (56) |
| 6/4 | | | | | | | 1,0 (72) | 1,3 (64) |
| 31/5 | | | | | | | | 1,3 (72) |

( )* Age in weeks.

February and other crops, which also lodged at 56 weeks of age and had lower yields.

The similarity of the results obtained from the crops that ratooned in January and February in two consecutive years confirmed that the results were typical of crops growing at this time of year. It is also possible to compare the December ratoon crop with the October and November plant crops because plant crops normally take longer than ratoon crops to become established. The October plant crop had thin stalks and both the October and November plant crops had low cane yields, and produced bull shoots, confirming the results obtained from the December ratoon crop.

*Sugar production and cane quality*

The data for ters/ha and ters/ha/month presented in Tables V and VI respectively, may be regarded as standards against which other well grown irrigated crops may be compared. The actual figures shown are less important in this respect than the relative differences between crops that were either harvested at different times of the year, or at different ages. From these data it is possible to determine what difference in yield there would be if a crop was harvested at a different time of the year. The results show that high yields of ters/ha/month can be obtained from young, well grown crops that are harvested early in the season. They also show that crops which start to lodge at the beginning of summer should not be allowed to carry over into the next season.

The practical interpretation of the data presented in this paper is limited because it was not possible to reduce irrigation prior to harvest (drying off). Drying off improves the purity and the sucrose concentration of sugarcane (Humbert[8], Thompson and Boyce[9]) but there is no reason to believe that it would have altered the results of this experiment appreciably. Presumably it would have accentuated the natural increases in dry matter content, purity and ers % that occurred with both increasing age and the onset of winter conditions.

Many factors must be taken into consideration in deciding what is the best time, or age at which to harvest a sugarcane crop, including the extra cost of harvesting younger crops more frequently than older crops in a given period of time and the low juice purity and ers % of young crops. It is possible that the procedure that gives maximum ters/ha/month will not coincide with the one that gives maximum profitability, and this can only be assessed by each grower for his own conditions. By judicious harvesting of crops of the right age at the right time of year it should be possible to obtain the maximum ters/ha/month in any one season. It will be more difficult to maintain maximum productivity over a number of years because the time of one harvest affects the yield potential of the next ratoon crop.

In conclusion, it must be emphasised that the results of this experiment refer to well established crops, grown on a rich soil with high levels of fertilizer application and adequate moisture. Similar results will only be obtained with a similar standard of management.


## Acknowledgements

I wish to thank Mr. J.P. Boyce and Mr. J. Duckworth for assistance in managing the experiment, Mr. M.G. Murdoch for advice and assistance in analysing the data, and staff of the chemistry department for leaf and stalk analyses.

This work is being used in post-graduate studies in the Department of Crop Science at the University of Natal.


## REFERENCES


1. **Pearson, C.H.O.** 1965. Harvesting frequency and its effect on yield, sugar recovery and the fibre content of cane. Proc. S.A. Sug. Tech. Ass. 39, 187-194.
2. **Gosnell, J.M.** 1968. Some effects of environmental factors and cultural treatments on the growth of sugarcane. Ph. D. Thesis, Dept. of Crop Science, University of Natal.
3. **Borden, R.J. and Denison, F.C.** 1942. A study of optimum crop length. Haw. Pl. Rec. 46, 119-137.
4. **Moberly, P.K.** 1971. The nitrogen requirments of ratoon crops of sugarcane in relation to age and time of harvest. Proc. S.A. Sug. Tech. Ass. 45, 205-211.
5. **Du Toit, J.L.** 1956. A study of the growth, sucrose accumulation and plant food uptake of sugarcane during successive months. Proc. S.A. Sug. Tech. Ass. 30, 114-121.
6. **Rostron, H.** 1971. The growth and productivity of sugarcane. Proc. S.A. Sug. Tech. Ass. 45, 152-157.
7. **Clements, H.F., Shigeura, G. and Akamine, E.K.** 1952. Factors affecting the growth of sugarcane. Univ. of Haw. Agr. Exp. Sta. Tech. Bull. No. 18.
8. **Humbert, R.P.** 1968. The growing of sugarcane. Elsevier, London, 1968.
9. **Thompson, G.D. and Boyce, J.P.** 1968. The plant crop results of two irrigation experiments at Pongola. Proc. S.A. Sug. Tech. Ass. 42, 143-153.