

THE NITROGEN REQUIREMENTS OF RATOON CROPS OF SUGARCANE IN RELATION TO AGE AND TIME OF HARVEST

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Abstract

Results are reported of an irrigated experiment designed to determine the optimum levels of nitrogen for ratoon cane when cut at different ages, and at different times of the year.

The adverse effects of excessive nitrogen on estimated recoverable sugar (e r s) are shown to be more extreme when young cane (12 months old) is cut at an unfavourable (May) compared with a favourable (November) time of the year. In contrast, the time of cutting is relatively unimportant, even at high levels of nitrogen, when the cane is 18 months of age.

The uptake of N is more efficient in crops grown during a favourable climatic cycle, viz. November to November or November to May, compared with a less favourable cycle, viz. May to May or May to November. Lower levels of nitrogen could be used, therefore, for crops grown during a favourable climatic cycle.

High levels of nitrogen would, in general, be more profitable when applied to long (18-month) rather than to short (12-month) ratoons.

The merits of a 12 month cutting cycle on the coast lowlands are questioned.

Introduction

Following the results of experiments reported by Pearson (1965)⁴, quicker cutting cycles were advocated in the belief that greater productivity would be obtained. The question then arose as to whether higher levels of nitrogen, commensurate with the expected higher level of production per hectare per

annum, should also be advocated. This paper reports the results of an experiment designed to answer that question.

Experimental

The experiment was situated at the S.A.S.A.'s Experiment Station farm at Shaka's Kraal on a Waldene (Dwyka) fine sandy loam.

The split plot technique, with six replications, in a randomised block design was used. The whole plots were used for the age at harvest treatments, and sub-plots for levels of nitrogen. The gross plots consisted of six rows, 12 m long and 1.4 m apart, and the net plots comprised two rows 10 m long.

The perforated pipe system of irrigation, as described by de Robillard and Stewart (1966)¹, was installed. A perf-o-rainer pipe was placed in every alternate inter-row rather than every inter-row. This saved on piping and labour requirements, and did not apparently upset the water distribution. Using a total available moisture (T.A.M.) of 75 mm and the profit and loss system of irrigation control, 25 mm of irrigation water (assuming 100% efficiency) were applied when the soil moisture deficit reached 38 mm. In this way, no serious moisture stress was suffered by the crop. Cylindrical gypsum soil moisture blocks were placed at depths of 15, 45, 75 and 105 cm in four of the six replications. The blocks were located half-way between the centre of the cane row and the centre of the inter-row, and readings were taken twice weekly with a Bouyoucos meter.

TABLE I
Planting and harvesting programme

Treatment	Plant	Harvest time and (age)							
		Nov. 1966	May 1967	Nov. 1967	May 1968	Nov. 1968	May 1969	Nov. 1969	May 1970
Cycle 1 12 Months 18 "	Sept 1965	PL(14)		R1(12)		R2(12)		R3(12)	
	Sept 1965	PL(14)			R1(18)			R2(18)	
Cycle 2 12 " 18 "	Sept 1965		PL(20)		R1(12)		R1(12)		R1(12)
	Sept 1965		PL(20)			R1(18)			R1(18)

PL = plant
R = ratoon crop

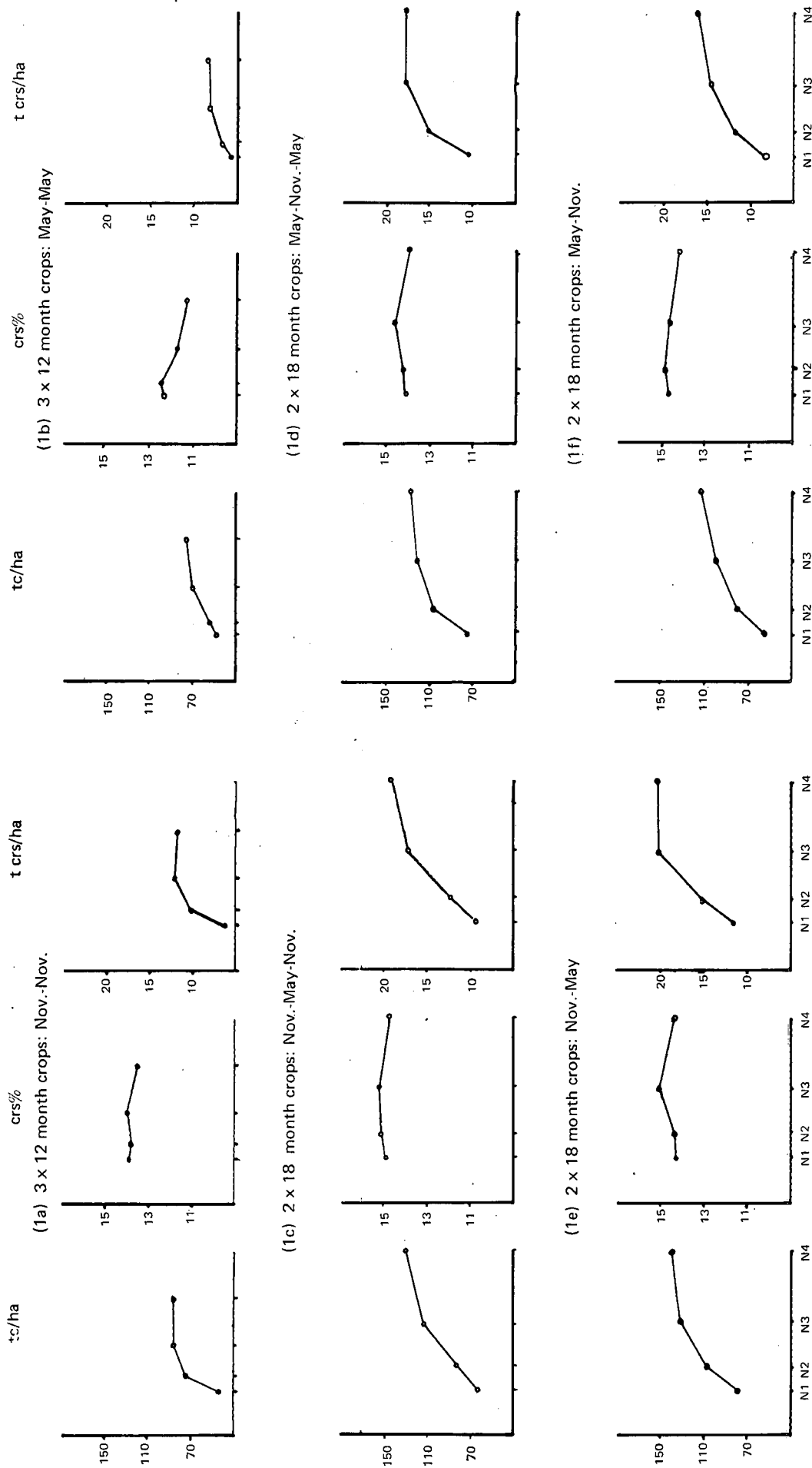


FIGURE 1: The mean response curves to nitrogen.

TABLE II
Harvest data and water use efficiency

	3 × 12 month crops Nov. — Nov				3 × 12 month crops May — May				2 × 18 month crops Nov. — May — Nov.				2 × 18 month crops May — Nov. — May			
	N1	N2	N3	N4	N1	N2	N3	N4	N1	N2	N3	N4	N1	N2	N3	N4
Total t c/ha	130,1	222,4	266,2	260,7	140,1	162,8	210,9	229,6	125,4	163,0	226,5	258,9	149,1	214,3	243,2	254,4
Total ers/ha	18,10	30,99	37,26	35,29	17,12	20,28	24,45	25,44	18,62	24,56	34,36	38,06	20,95	30,29	35,72	35,54
Mean ers	13,9	13,8	13,9	13,5	12,4	12,5	11,8	11,3	14,9	15,1	15,2	14,7	14,1	14,2	14,6	13,9
t c/ha/month	3,61	6,24	7,39	7,24	3,89	4,52	5,86	6,38	3,48	4,53	6,29	7,19	4,14	5,95	6,76	7,07
T ers/ha/month	,50	,86	1,04	,98	,47	,56	,68	,71	,52	,68	,95	1,06	,58	,84	,99	,99
Mean stalk count 10 ⁻³ /ha	91	114	126	129	94	112	120	128	101	108	123	127	100	112	127	128
Mean stalk length cm	114	147	153	145	110	112	128	130	161	191	203	213	161	176	204	224
Mean stalk weight kg	,48	,66	,71	,68	,50	,48	,59	,60	,62	,79	,93	1,03	,74	,99	,95	,99
t c/100 mm water	3,1	5,3	6,3	6,1	3,6	4,2	5,5	6,0	2,9	3,8	5,3	6,1	3,8	5,4	6,1	6,4
t ers/100 mm water	,43	,73	,89	,83	,45	,53	,64	,67	,44	,56	,81	,89	,53	,76	,90	,90

Treatments

The whole plot treatments were 12- and 18-month harvest cycles. By starting the experiment at different times, different climatic cycles were incorporated, thus permitting the following ratoon comparisons to be made over a 36-month period:—

- 3 x 12-month crops from May to May
- 3 x 12-month crops from November to November
- 2 x 18-month crops from May to November to May
- 2 x 18-month crops from November to May to November

Heat-treated seed of variety NCo 376 was planted in September 1965 and the harvesting programme was carried out as illustrated in Table I.

The sub-plot treatments comprised four levels of nitrogen in the form of urea. The four nitrogen levels, tested over the 36-month period, were: N1 : no nitrogen, N2 : 112 kg, N3 : 336 kg and N4 : 672 kg N per ha. These quantities were evenly divided for each crop, e.g. each ratoon received either 168 kg or 112 kg N/ha for an 18-month and a 12-month cycle respectively, in the case of the N3 level of nitrogen. The same quantities of superphosphate and potassium chloride were applied to all treatments.

The plant crop data are ignored for the purpose of this paper because the treatment comparisons start with the first ratoon crops.

Results

The response to applied nitrogen has been considerable in all crops. The level of response obtained is what might be expected in ratoon crops on a Dwyka derived soil (Du Toit, 1959²).

Yield data

The nitrogen response curves for the four different cycles are illustrated graphically in Figures 1 (a), (b), (c) and (d), and the response curves for the two 18-month crops, November to May and May to November, are illustrated in Figures 1 (e) and (f). The data for Figures 1 (e) and 1 (f) are obtained from different plots and are not from consecutive ratoons, but the comparison of yields from these two climatic cycles is of interest.

It is evident, for the favourable climatic cycles, viz. November to November, and November to May, that there is no response in t ers/ha to levels

higher than N3. In contrast, for the less favourable climatic cycles, viz. May to May and May to November, the need for nitrogen at levels greater than N3 for maximum cane production is evident. The comparatively severe reduction in ers with increasing nitrogen levels in the May to May cycle results in the ers/ha reaching a peak at approximately the N3 level. The adverse effect of high nitrogen levels on ers is comparatively slight when the age at harvest is 18 months, or when 12-month cane is harvested at a time when sucrose % cane is naturally high, in November.

There is evidence that 18-month-old crops benefit more from high levels of nitrogen than do the younger crops of 12 months of age. The harvest and water use efficiency data for the four different cycles are given in Table II, and the data for the two 18-month crops harvested in November and May are given in Table III.

The water use efficiency is seen to increase with increasing levels of applied nitrogen for both tons cane and tons ers, with the exception of the November to November crop, where maximum efficiency occurs at the N3 level. The efficiency of water use in terms of tons ers is lowest for the May to May cycle and tends to be better in the November to May cycle compared with the May to November cycle.

The two highest levels of nitrogen have caused soil moisture to be extracted at greater depths down the profile than have the N1 and N2 levels. These differences in soil moisture extraction patterns are clearly visible in the graphic presentation of gypsum block data in Figure 2. These data are from the 12-month May to May first ratoon crop, and are typical of the patterns produced by the other crops.

The increase in yield, as can be seen in Table II, is due to the marked increase in stalk population, an increase in stalk height, and consequently an increase in the individual stalk weight. The increase in stalk population per level of N is remarkably consistent for all crop cycles. A typical stalk population development pattern, with the characteristic peak population occurring in mid-summer, is illustrated graphically in Figure 3, for a 12-month May to May ratoon crop.

The harvest data from all the 12- and 18-month crops are presented in Table IV.

TABLE III

The mean harvest data and water use efficiency from two 18 month crops harvested in May and November

	2 × 18 month crops, R1 and R2 Nov. — May				2 × 18 month crops, R1 and R2 May — Nov.			
	N1	N2	N3	N4	N1	N2	N3	N4
Mean tc/ha/month	4,54	6,02	7,47	7,90	3,08	4,46	5,57	6,36
Mean ers	14,3	14,4	15,1	14,4	14,7	14,9	14,7	14,3
Mean ers/ha/month	,65	,86	1,13	1,14	,45	,66	,82	,91
tc/100 mm water	3,6	4,8	5,9	6,3	3,0	4,4	5,5	6,3
ters/100 mm water	,51	,68	,89	,90	,45	,65	,81	,89

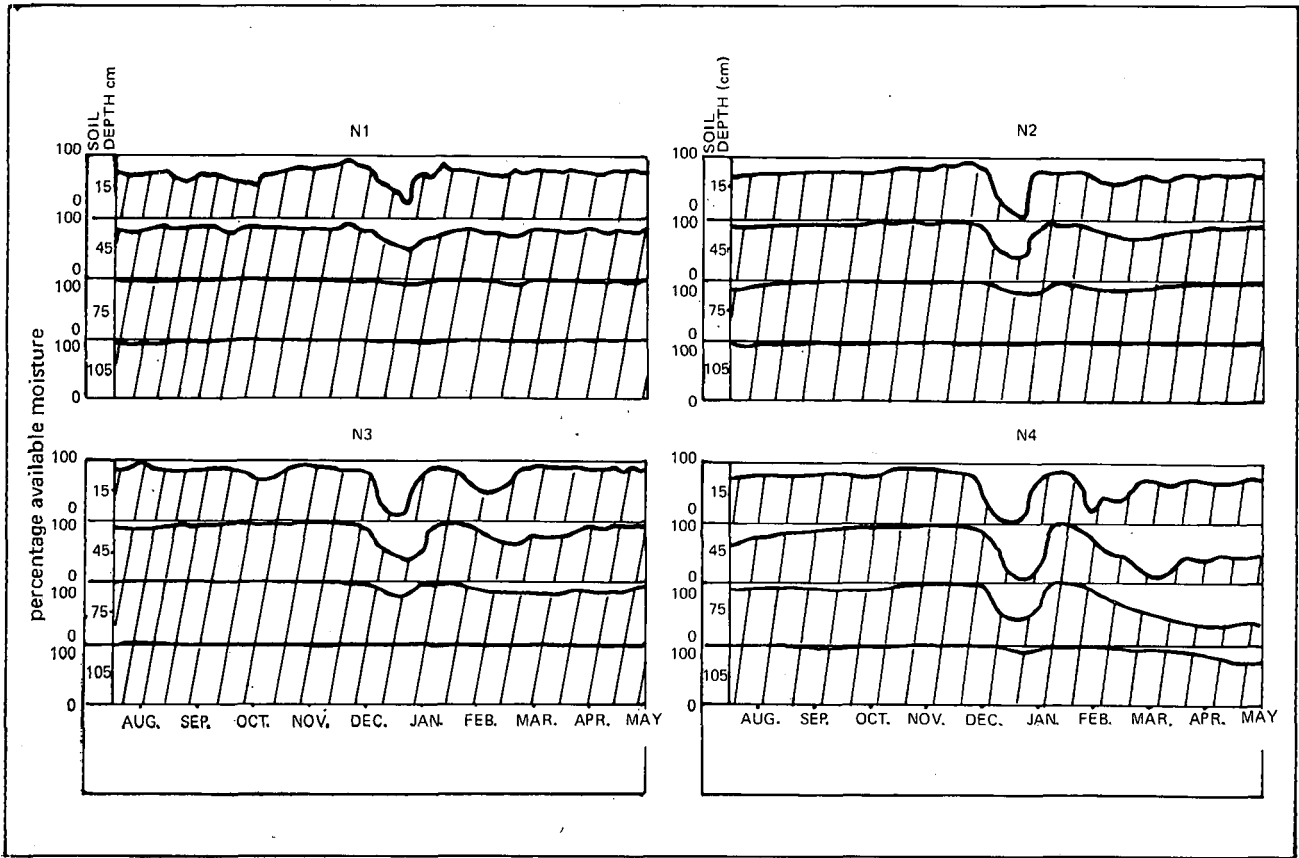


FIGURE 2: The gypsum block data for treatments N₁, N₂, N₃ and N₄ for a 12-month crop from May to May.

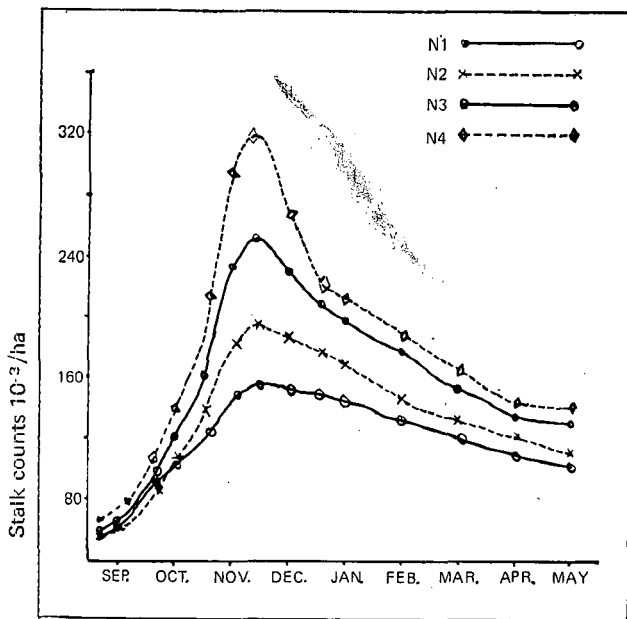


FIGURE 3: The effect of nitrogen levels on stalk population.

Taking the favourable and unfavourable cycles together, which is inevitable in practice, the results indicate a greater return per unit of nitrogen from an 18-month crop compared with a 12-month crop. It is very evident, too, that nitrogen levels greater than N₃ should only be contemplated for crops to be harvested when more than 12 months of age.

The ratios of kg N applied to tons cane and tons

ers per hectare, for the different cycles, are tabulated in Table V.

For the two favourable climatic cycles, viz. November to November, and November to May, the ratio, at the near optimum level of nitrogen (N₃), is 1.3. This agrees well with present-day recommendations of 1.25 kg N per ton of cane expected. However, for the less favourable climatic cycles the optimum ratio appears to be greater, viz 1.6-1.7, because of the lower efficiency of nitrogen usage.

Conclusions

The S.A.S.A. Experiment Station's Fertilizer Advisory Service (F.A.S.) recommends that 1.25 kg N be applied per ton of cane expected per hectare. This is generally well supported by the data presented. However, there is evidence that crops grown during less favourable climatic cycles require more nitrogen because of the apparent less efficient uptake of nitrogen.

The decline in cane quality with increasing nitrogen levels is understandably more marked when young, immature cane is harvested during the natural sucrose trough period.

In general, less nitrogen should be applied to short ratoon crops, and high levels of nitrogen only to ratoons to be harvested at approximately 18 months of age or older.

There is evidence that water use efficiency increases with increasing levels of nitrogen up to the level

which is optimum for cane production. This trend is confirmed by Hawaiian work reported by Isobe (1968)³. The higher levels of nitrogen have induced water extraction at greater depths in the profile.

Unlike the data presented by Pearson (1965)⁴ these results do not indicate an increase in yield per ha per unit of time with quicker cutting cycles. On the contrary, under the conditions obtaining in this experiment, there is considerable advantage to be gained in terms of the ers/ha, by harvesting 18-month compared with 12-month-old cane. This is particularly true at the high levels of nitrogen and is due, primarily, to the higher ers % cane of the 18-month-old crops.

It is considered that climate plays such an important rôle in the determination of yield, that age *per se* is relatively unimportant. It is suggested that the criteria for harvesting cane should be estimated yield and quality, and that age should be a secondary consideration.

Acknowledgements

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TABLE IV

Harvest data from all 12 month and 18 month crops

	6 × 12 month crops Nov. and May harvests				4 × 18 month crops Nov. and May harvests			
	N1	N2	N3	N4	N1	N2	N3	N4
Total production in 3 yrs. tc/ha	270,2	387,3	477,1	490,3	274,5	377,3	469,7	513,3
Total production in 3 yrs. ters/ha	35,2	51,3	61,7	60,7	39,6	54,9	70,1	73,6
Mean ers in 3 yrs.	13,1	13,1	12,9	12,4	14,5	14,7	14,9	14,3
Mean tc/ha/month	3,8	5,4	6,6	6,8	3,8	5,2	6,5	7,1
Mean ers/ha/month	,49	,71	,86	,84	,55	,76	,97	1,02

TABLE V

The mean ratios of Kg N : t c/ha and t ers/ha for the four crop cycles

	Nov. — Nov. 12 months			May — May 12 months			Nov. — May 18 months			May — Nov. 18 months		
	N2	N3	N4	N2	N3	N4	N2	N3	N4	N2	N3	N4
Kg N:t c/ha	0,5	1,3	2,6	0,7	1,6	2,9	0,5	1,3	2,3	0,7	1,7	2,9
Kg N:t ers/ha	3,6	9,0	19,1	5,6	13,7	26,4	3,6	8,3	16,4	4,7	11,3	20,6

Discussion

Mr. du Toit: In a paper like this there is a possible danger of extrapolating results for a whole industry. However, I feel this paper will have a significant influence on our future agricultural practice.

I think the experiment described in the paper shows conclusively that the nitrogen use is such that increased crops are obtained and increasing use is made of rainfall. The results of the 18 month crop are significantly better than that of the 12 month crop. With the introduction of ERS and in particular the 'millers right' cane quality will become of utmost importance.

In the 12 month crop the sucrose is barely 13%

but with the 18 month crop it is about 14,5%—an enormous increase for an additional six months.

Mr. Rostron: Mr. Moberly claims that during growth under unfavourable conditions more nitrogen is needed. This will surely depend on when it is applied i.e. if applied in the spring results could be different.

Mr. Moberly: When the crop was harvested in May the top dressing with nitrogen was done in spring (August), and when cut in November the nitrogen was applied about December.

Dr. MacVicar: In some cases in the unfavourable cycle the N4 figure showed a good nitrogen response and yet in Table V the N3 figure is referred to.

Mr. Moberly: In the long cycles, the unfavourable

cycle—May to November or equivalent—warrants high levels of nitrogen. It is not dangerous to apply high levels of N if cutting is to be at 18 months of age because it is less likely to have an adverse effect on cane quality, even if cutting is done during a natural sucrose trough period. For the favourable long cutting cycle the nitrogen appears to be used more efficiently and therefore less need be applied, and in this case the N3 level would be the optimum for the favourable long cycle. A figure between N3 and N4 would probably be optimum for the favourable long cycle.

Mr. Landrey: The experiment was irrigated to ensure there was no moisture stress. Does it mean therefore that the conclusions apply only to irrigated, and not dry land, conditions?

Mr. Moberly: I do not know. But, had there been a severe drought during any period there is the likelihood that the response to N would not have been above N2 level because nitrogen use is very poor under drought conditions, but I think the trend would have been the same as recorded in this experiment.

Mr. Pearce: There is also an economic consideration. When land is exposed to sun and rain without cover it affects costs. Under these circumstances the 18 month crop will surely be a more economical proposition than the 12 month crop.

Mr. Mann: The balance of the crop, that is, the percentage area harvested each year must be considered. If a check is not kept on the age factor when cutting cane then the tendency is to cut a big crop in a wet year and in a dry year the effect of a drought will be accentuated because a small percentage of land area will be available for cutting.

In the past most of the young cane was cut towards the end of the season and this puts it through a short cutting cycle in an unfavourable season. Management can change this so that on good land, capable of producing short cycle crops, cane could be cut at 12 months in a favourable cycle. But to plan a favourable 18 month cycle is simply not possible.

Mr. Moberly: We certainly cannot ignore age and we must plan carefully. But emphasis must be more on size of crop than on age.

Dr. Shuker (in the chair): Estates with which we are associated which have placed the emphasis as Mr. Moberly suggests have certainly made the largest profits over the last ten years.

Mr. Andries: I suggest similar experiments should be run to include cycles of 16 and 22 months in view of the possible introduction of an ERS system.

Mr. Moberly: Undoubtedly more data for different cycles and for different environments would be of great value.