THE USE OF FRS DATA TO INTERPRET THE EFFECT OF DIFFERENT GROWTH CYCLES ON THE YIELD PERFORMANCE OF VARIETY N12

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Abstract

The computer software enabling the effective operation and use of the Field Record System (FRS) data on personal computers has now been developed. This Facility makes it possible to identify, measure and reduce the variability that exists within FRS data. The introduction of statistical measurements, makes it possible to interpret the differences between treatments in a more reliable manner. These measurements are used to compare the effects of different growth cycles on the yield performance of variety N12 in the Midlands South extension area.

Introduction

Yield data captured through the Field Record System (FRS) are a measure of sugarcane performance under commercial conditions. Under these conditions there are many variables which contribute to the sucrose yield obtained from individual fields. Some of these variables, such as variety, soil type, crop status, crop age and growth cycle can be defined, whereas others such as level of management, rainfall distribution, extent of weed infestation and waterlogging are difficult to assess.

A large quantity of data are captured through FRS each year. During the period 1987/88 to 1991/92 information from 3 153 fields was recorded for the Midlands South extension area. A convenient method of using these data has been to summarise the yield data and determine a mean value for each variable. Although these summaries provide a record of what occurred in a particular season, erroneous conclusions can be drawn when the means are presented in the summaries. Hellmann (1988) found that a major factor contributing to these errors was the large variability that existed between the individual fields comprising the mean. Although this variability could be attributed to natural field conditions, some of the variability could be ascribed to limitations in the extraction of specific data from the record system. The computer software required to overcome these limitations and to manipulate the data extracted has now been developed.

The analysis of field records will establish the yield for a given set of conditions, but does not explain why a particular yield was obtained. It is expected that the crop growth model being developed (Inman-Bamber, 1991b) will make it possible to predict the yield for the same set of conditions. Any differences between predicted and measured yields will assist in identifying those factors which could be limiting cane production. This paper demonstrates how this system can be used to measure and reduce the variability, and make valid comparisons of the effects of different growth cycles on the yield of N12.

Method

Area from which data were collected

The Midlands South extension area is comprised mostly of the farms which supply the Illovo sugar mill. Rainfall varies from 600 to 950 mm per annum and altitude from 600 to 950 metres. Most soils are derived from TMS (ordinary) and Dwyka tillite, with smaller areas derived from TMS (mistbelt), dolerite and Lower Ecca shale parent materials.

Data used in the investigation

This investigation included fields harvested during the 1991/92 season. Rainfall data were obtained from the six met stations located in the district. The mean rainfall for the period January 1989 to June 1991 is shown in Figure 1.

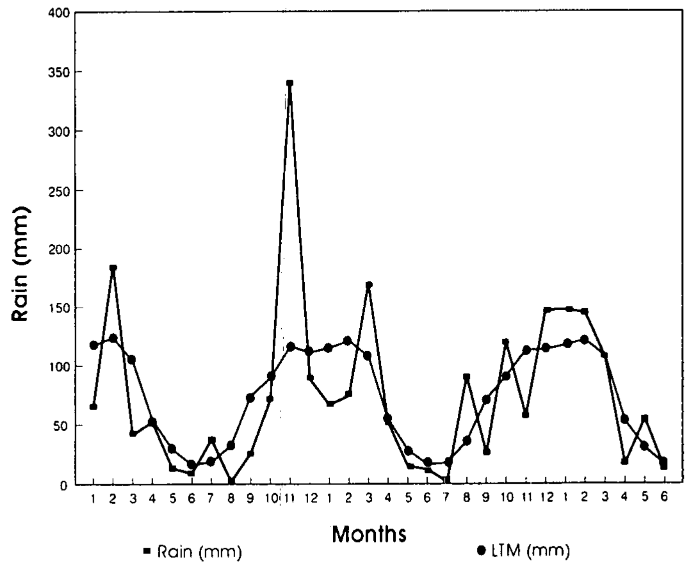

FIGURE 1 Mean rainfall from six met stations in the Midlands and the long term mean for the period January 1989 to June 1991.

Field data used were obtained from the records of 27 FRS participants (21 cane growers and six miller-cum-planter estates). A summary of the total yield data collected during the 1991/92 season and the information pertaining to variety N12 are given in Table 1.

Table 1

Summary of yield data submitted by FRS participants for the 1991/92 season

	No. fields	Area (ha)	Age (mths)	tc/ha	tc/ha/ mth	ts/ha	ts/ha/ mth	S % (rel)
All fields	1 032	6373,7	20,9	95,0	4,6	13,2	0,63	13,9
Variety N12	547	3260,1	21,8	105,1	4,8	14,9	0,69	14,1

By using relative sucrose per cent, the influence of the time of harvest on sucrose yields is reduced and is therefore a more reliable indicator when interpreting FRS data.

Variety N12 accounted for 53% of the fields harvested, 51% of the area harvested and 58% of the sucrose produced during the review period. NCo376 is the second most important variety, accounting for only 19% of the area harvested and 17% of the sucrose produced. The higher yielding characteristics of N12 in comparison with NCo376 in the Midlands South area have been reported by Harding (1992). For this reason this investigation considers only the variety N12.

Manipulation of yield data

Fields were ranked in terms of tc/ha, grouped and plotted in a frequency distribution as illustrated in Figure 2. This is expressed in two forms; the number of fields in each group as a percentage of the total fields harvested, and the area in each group as a percentage of the total area harvested.

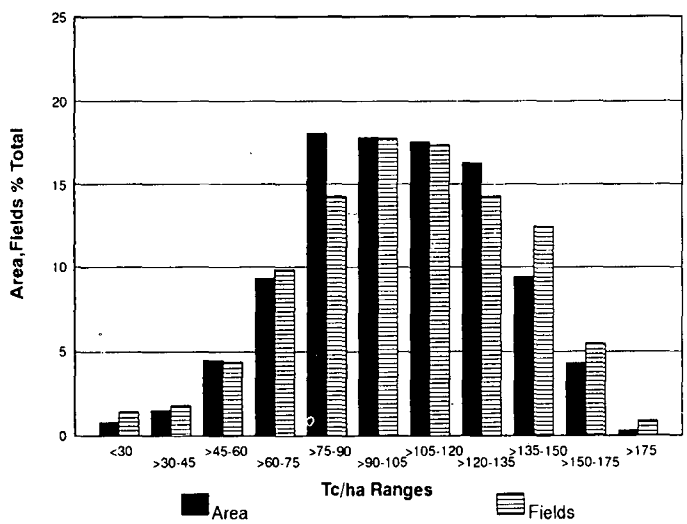

FIGURE 2 Frequency distributions of area (as percentage of total area) and number of fields (as percentage of total fields) for different tc/ha ranges.

The arithmetic mean of the treatment is considered preferable to a weighted mean, although the data presented in Figure 2 indicate that in most instances they do not differ markedly.

The mean age at harvest, tc/ha/month, relative ts/ha/month, and the relative sucrose per cent cane were then determined for each of the tc/ha ranges. The coefficient of variation (CV%) was also determined for each mean (Table 2).

The initial interpretation of these data indicates that the increase in tc/ha is associated with an increase in crop age at harvest, tc/ha/month, ts/ha/month and relative sucrose per cent cane; but a high CV% was recorded for a number of the means presented. A possible valid reason for some of the variability could be valley bottom fields being harvested on an annual basis and producing high tc/ha/month yields; but other factors could be contributing to the variability. For example, the inclusion of fields with low yields as a result of waterlogging or weed infestations, errors from small fields, incorrect areas or incorrect recording by the FRS participant. It was therefore necessary to scan the data and reject fields which did not conform to certain standards which were:

- > 8,3 tc/ha/month
- > 175 tc/ha
- < 80 total tons of cane per field
- < 30 tc/ha
- < 2,6 tc/ha/month

Excluding fields of less than 80 tons of cane was used as a practical alternative to rejecting small fields. All growers haul their cane in interlinks with a payload of about 26 tons, and yield measurements based on less than four consignments could be inaccurate.

Using these standards, a total of 63 fields were rejected. The frequency distribution presented in Figure 3 indicates that the exclusion of these fields has not seriously affected the distribution. A comparison of the mean yield data and the CV% values for all the fields and for the situation once the 63 fields had been excluded is given in Table 3. Although the mean values have not been markedly affected there has been a considerable reduction in the variability of the data.

Growth cycles investigated

Preliminary observations of the data indicated that the yield differences between cane producers within a homogenous area are greater than the yield differences between the homogenous areas. It was therefore decided that the different growth cycles would be investigated on a whole district basis.

It was evident that of the 484 fields included in the growth cycle analysis, 216 were plant crop fields. This high proportion of plant crops reflects the rate at which variety N12 is expanding in the Midlands South area.

Table 2

N12 yield data and CV% values for different tc/ha ranges

tc/ha range	No. fields	Fields % total	Area	Area % total	Age		tc/ha/mth		ts/ha		ts/ha/mth		Sucrose %	
					Mean	CV %	Mean	CV %	Mean	CV %	Mean	CV %	Mean	CV %
<30	8	1,5	25,8	0,8	13,4	41,0	2,1	30,6	3,3	19,2	0,27	31,6	12,96	14,7
>30–45	10	1,8	49,9	1,5	17,2	32,8	2,6	29,8	5,0	14,2	0,31	26,5	12,40	7,6
>45–60	24	4,4	146,0	4,5	18,4	27,2	3,2	26,7	7,2	9,8	0,42	23,2	13,24	9,9
>60–75	54	9,9	304,4	9,3	20,0	18,7	3,5	19,4	9,7	11,8	0,50	16,8	14,10	7,4
>75–90	78	14,3	589,5	18,1	20,7	21,4	4,2	26,3	11,6	10,0	0,59	23,9	13,96	8,5
>90–105	97	17,7	580,1	17,8	21,5	14,3	4,7	17,6	13,9	7,9	0,66	15,9	14,25	6,6
>105–120	95	17,4	573,0	17,6	22,2	14,5	5,2	17,5	16,1	7,0	0,74	17,0	14,37	6,2
>120–135	78	14,3	530,7	16,3	23,4	12,0	5,5	11,1	18,3	6,6	0,79	12,0	14,38	5,3
>135–150	68	12,4	307,7	9,4	24,0	14,3	6,1	18,8	20,3	7,1	0,86	18,4	14,24	6,8
>150–175	30	5,5	141,1	4,3	23,8	9,7	6,7	13,4	22,5	6,0	0,95	13,1	14,27	5,8
>175	5	0,9	11,9	0,4	23,3	8,1	8,2	9,4	26,5	4,4	1,14	8,0	14,04	2,5

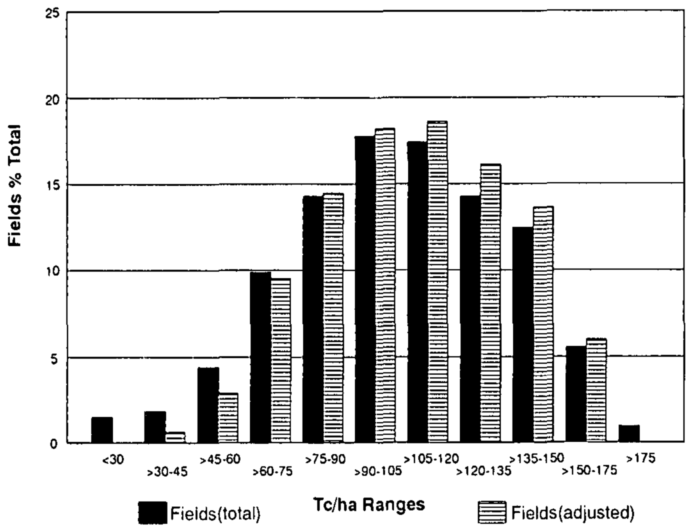

FIGURE 3 Frequency distribution of original and adjusted data (expressed as number of fields as % of total fields) for different tc/ha ranges.

After scanning the data and identifying the number of fields associated with each possible growth cycle, the following cycles were investigated:

- Plant crop:

Autumn (1 summer's growth)	PA * 1S
Autumn (2 summers' growth)	PA * 2S
Spring/winter to winter (2 summers' growth)	PS to W * 2S
Spring/summer to spring/summer (2 summers' growth)	PS to S * 2S

- Ratoon crops (2 summers' growth):

Winter to winter	RW to W * 2S
Winter to spring/summer	RW to S * 2S
Spring/summer to winter	RS to W * 2S
Spring/summer to spring/summer	RS to S * 2S

- Ratoon crops (1 summer's growth):

Winter to spring/summer	RW to S * 1S
Spring/summer to spring/summer	RS to S * 1S

In this context autumn, winter and spring/summer are defined as follows:

Autumn	: February to April
Winter	: May to July
Spring/summer	: August to December

Results

Comparison of growth cycles

The mean yield data, standard deviation and CV% values for each of the growth cycles are presented in Table 4.

In comparing the different growth cycles it was necessary to consider the number of fields making up each mean and the associated variability. For this the standard error of the difference of the means (SEDM) was determined using the following formula:

$$\text{SEDM} = \sqrt{\frac{\text{SD}^2}{\text{N}} + \frac{\text{SD}^2}{\text{N}}}$$

where SD = standard deviation of one treatment mean
N = number of observations in the treatment mean.

From a possible number of treatment comparisons, 10 of the more important were selected. The differences between growth cycles and the corresponding SEDM values are shown in Table 5.

Multiplying the SEDM by two and then adding and subtracting this value to and from the difference of the treatment means determines the 95% confidence limits for the comparison. This range will confidently indicate the magnitude of the difference between treatment means when comparisons are made. The 95% confidence limits for the tc/ha and ts/ha/mth comparisons made in Table 5 are given in Table 6.

Table 3

A comparison of original and adjusted N12 yield data and CV% values for different tc/ha ranges

tc/ha range	No. fields		Area		Age		tc/ha/mth		ts/ha		ts/ha/mth		Sucrose %	
	orig.	adj.	orig.	adj.	orig.	adj.	orig.	adj.	orig.	adj.	orig.	adj.	orig.	adj.
<30	8		25,8		13,4		2,1		3,3		0,27		12,96	
>30-45	10	3	49,9	14,6	17,2	13,8	2,6	3,0	5,0	5,0	0,31	0,37	12,40	12,37
>45-60	24	14	146,0	90,6	18,4	17,5	3,2	3,4	7,2	7,4	0,42	0,43	13,24	13,07
>60-75	54	46	304,4	291,2	20,0	19,7	3,5	3,6	9,7	9,7	0,50	0,50	14,10	14,12
>75-90	78	70	589,5	578,8	20,7	20,9	4,2	4,1	11,6	11,7	0,59	0,58	13,96	14,07
>90-105	97	88	580,1	574,6	21,5	21,3	4,7	4,7	13,9	14,0	0,66	0,67	14,25	14,29
>105-120	95	90	573,0	570,1	22,2	22,5	5,2	5,1	16,1	16,2	0,74	0,73	14,37	14,39
>120-135	78	78	530,7	530,7	23,4	23,4	5,5	5,5	18,3	18,3	0,79	0,79	14,38	14,38
>135-150	68	66	307,7	306,0	24,0	24,2	6,1	6,0	20,3	20,3	0,86	0,85	14,24	14,23
>150-175	30	29	141,1	139,7	23,8	24,1	6,7	6,6	22,5	22,5	0,95	0,94	14,27	14,30
>175	5		11,9		23,3		8,2		26,5		1,14		14,04	
					Coefficient of variation									
<30					41,0		30,6		19,2		31,6		14,7	
>30-45					32,8	13,3	29,8	12,3	14,2	7,5	26,5	9,5	7,6	4,6
>45-60					27,2	18,3	26,7	21,5	9,8	9,5	23,2	16,1	9,9	8,8
>60-75					18,7	18,0	19,4	18,5	11,8	11,8	16,8	15,6	7,4	7,7
>75-90					21,4	18,7	26,3	23,5	10,0	9,6	23,9	21,3	8,5	7,4
>90-105					14,3	13,8	17,6	17,8	7,9	7,8	15,9	15,8	6,6	6,6
>105-120					14,5	13,4	17,5	14,8	7,0	7,1	17,0	14,8	6,2	6,3
>120-135					12,0	12,0	11,1	11,1	6,6	6,6	12,0	12,0	5,3	5,3
>135-150					14,3	12,6	18,8	12,6	7,1	7,2	18,4	12,0	6,8	6,9
>150-175					9,7	7,4	13,4	9,3	6,0	6,0	13,1	10,6	5,8	5,8
>175					8,1		9,4		4,4		8,0		2,5	

Table 4

The mean yield data, standard deviation and CV % values for different growth cycles

Growth cycle	No. fields	Area (ha)	Age		tc/ha		tc/ha/mth		ts/ha		ts/ha/mth		Sucrose	
			Act	CV %	Act	CV %	Act	CV %	Act	CV %	Act	CV %	Act	CV %
RS-S*2S	72	523,4	23,6	5,3	119,7	19,6	5,1	19,5	17,8	19,8	0,75	19,6	14,9	5,9
RS-W*2S	80	526,9	20,7	6,9	106,6	24,1	5,2	23,9	15,5	23,5	0,75	23,5	14,6	4,1
PS-S*2S	100	580,3	24,0	6,6	123,5	19,8	5,1	19,1	17,6	20,3	0,73	19,2	14,3	5,3
RS-S*1S	19	162,25	14,0	11,3	76,3	17,4	5,5	22,4	10,0	20,4	0,72	23,2	13,1	7,5
PS-W*2S	55	370,9	21,0	6,2	109,5	19,5	5,2	19,6	14,9	18,2	0,71	17,9	13,6	6,2
PA*2S	10	36,4	26,7	5,7	126,8	18,3	4,8	19,7	18,0	18,5	0,68	19,7	14,3	6,5
PA*1S	43	212,0	18,8	10,2	90,4	22,6	4,9	25,8	12,1	25,3	0,65	27,8	13,3	7,3
RW-W*2S	52	371,4	23,8	5,7	102,6	23,2	4,3	23,4	15,2	23,2	0,64	23,1	14,8	4,2
RW-S*1S	19	164,7	15,7	9,0	71,2	28,2	4,5	29,2	9,7	32,7	0,62	34,0	13,5	5,5
RW-S*2S	22	104,5	27,4	5,6	108,3	22,7	4,0	21,5	15,8	24,7	0,58	23,2	14,6	5,7

Standard deviation

Growth cycle	Age	tc/ha	tc/ha/mth	ts/ha	ts/ha/mth	Sucrose
RS-S*2S	1,2	23,4	1,0	3,5	0,15	0,9
RS-W*2S	1,4	25,7	1,2	3,6	0,18	0,6
PS-S*2S	1,6	24,5	1,0	3,6	0,14	0,8
RS-S*1S	1,6	13,3	1,2	2,0	0,17	1,0
PS-W*2S	1,3	21,3	1,0	2,7	0,13	0,8
PA*2S	1,5	23,2	0,9	3,3	0,13	0,9
PA*1S	1,9	20,4	1,3	3,1	0,18	1,0
RW-W*2S	1,4	23,8	1,0	3,5	0,15	0,6
RW-S*1S	1,4	20,1	1,3	3,2	0,21	0,7
RW-S*2S	1,5	24,6	0,8	3,9	0,13	0,8

Table 5

Yield differences and associated SEDM values for various growth cycle comparisons

Growth comparison	Age (mths)	tc/ha	tc/ha/mth	ts/ha	ts/ha/mth	Sucrose %
(PA*2S)-(PA*1S)	7,9	36,4	−0,11	5,9	0,03	0,93
SEDM	0,6	8,0	0,35	1,2	0,05	0,33
(PS-S*2S)-(PS-W*S2)	3,0	14,0	−0,09	2,8	0,02	0,67
SEDM	0,2	3,8	0,17	0,5	0,02	0,14
(RS-S*1S)-(RW-S*1S)	−1,7	5,1	0,97	0,3	0,10	−0,46
SEDM	0,5	5,5	0,41	0,9	0,06	0,28
(RS-S*2S)-(RW-W*2S)	−0,2	17,0	0,75	2,6	0,11	0,06
SEDM	0,2	4,3	0,18	0,6	0,03	0,14
(RS-S*2S)-(RW-S*2S)	−3,8	11,3	1,12	2,0	0,18	0,31
SEDM	0,4	5,9	0,22	0,9	0,03	0,21
(RS-S*2S)-(RS-W*2S)	2,9	13,1	−0,08	2,3	0,00	0,29
SEDM	0,2	4,0	0,18	0,6	0,03	0,12
(PS-S*2S)-(PA*2S)	−2,7	−3,3	0,37	−0,4	0,05	0,0
SEDM	0,5	7,7	0,31	1,1	0,04	0,3
(PS-S*2S)-(PA*1S)	5,2	33,0	0,26	5,5	0,08	1,0
SEDM	0,3	4,0	0,22	0,6	0,03	0,2
(RS-S*1S)-(RW-W*2S)	−9,7	−26,3	1,2	−5,2	0,08	−1,7
SEDM	0,4	4,5	0,3	0,7	0,04	0,2
(RS-S*1S)-(RS-S*2S)	−9,5	−43,3	0,4	−7,8	−0,03	−1,8
SEDM	0,4	4,1	0,3	0,6	0,04	0,2

Table 6

96% confidence limits for tc/ha and ts/ha/mth yields for various growth cycle comparisons

No.	Growth cycle comparison	tc/ha		ts/ha/mth	
		Diff	95%	Diff	95%
1	(PA*2S)-(PA*1S)	36,4	20,4 52,3	0,03	−0,07 0,13
2	(PS-S*2S)-(PA*2S)	−3,3	−18,9 12,2	0,05	−0,03 0,14
3	(PS-S*2S)-(PA*1S)	33,0	25,1 41,0	0,08	0,02 0,14
4	(PS-S*2S)-(PS-W*2S)	14,0	6,4 21,5	0,02	−0,02 0,07
5	(RS-S*2S)-(RS-W*2S)	13,1	5,1 21,1	0,00	−0,05 0,06
6	(RS-S*2S)-(RW-S*2S)	11,3	−0,5 23,3	0,18	0,11 0,24
7	(RS-S*2S)-(RW-W*2S)	17,0	8,4 25,6	0,11	0,06 0,17
8	(RS-S*1S)-(RW-W*2S)	−26,3	−35,3 −17,3	0,08	−0,01 0,17
9	(RS-S*1S)-(RW-S*1S)	5,1	−5,9 16,2	0,10	−0,03 0,22
10	(RS-S*1S)-(RS-S*2S)	−43,3	−51,5 −35,1	−0,03	−0,12 0,05

Influence of individual cane producers on yield variability

The yield data and CV% values from five FRS participants for the autumn plant * 1 summer crop cycle (Table 7) were selected to demonstrate the variability that exists in yield data both between and within individual cane producers.

Discussion

Rainfall

Rainfall data shown in Figure 1 represent one of the better rainfall distributions recorded in the area during the past 11 years. The 1989 spring was drier than normal which could have had a negative effect on fields planted then. A large proportion of the soils in the district have an impervious layer. This is considered an advantage when periods of high rainfall are followed by dry periods, because it ensures that waterlogging does not occur on a large scale in these soils.

The 1990/91 summer was exceptionally good in terms of rainfall, and growth cycles which included one summer were therefore at an advantage.

Manipulation of data

Extraction and manipulation of data from FRS were made possible through the database and spreadsheet facilities provided by Lotus 3.1 software. This system could become a powerful extension tool, either when dealing with FRS participants on an individual or group basis, or when conducting investigations such as this. The wide range of tc/ha yields for one season (Figure 2) and the age related variability that exists within each defined tc/ha range (Table 2) are cause for concern. It is relatively easy to identify the reasons for the low yielding fields, such as low population, weed infestation and disease infection, but understanding the conditions required to produce the high yields is more difficult. It is expected that the growth model (Inman-Bamber, 1991b) will eventually be able to identify the reasons for these high yields. It is noteworthy that the rejection of fields which do not conform to certain standards has not markedly affected the mean values initially determined, but has had a favourable effect on the variability (Table 3 and Figure 3). It must be stressed that these standards will vary from one area to another and those presented in this paper should not be accepted as a recipe for other areas. Three other standards which should have been included, but which were identified only towards the end of the data analysis, were:

- fields which were three years old
- summer planted fields harvested the following season
- fields with harvest dates which did not coincide with the milling season, i.e. fields harvested or partly harvested for seedcane during the off-crop.

If these standards had been included, an additional 12 fields would have been excluded from the frequency distributions.

Growth cycles

Over the last decade growers have been encouraged to harvest cane at a younger age. Although there are high potential fields (usually in valley bottoms) which can be harvested at a young age, it is unlikely that the majority of fields on a farm will perform in a similar manner. Inman-Bamber (1991a) has demonstrated that, if the economics of cane production are considered, the harvesting of young cane on a whole farm basis may not be an economic option. It was therefore important to investigate the different growth cycles.

The data in Table 4 indicate that all fields which were planted or ratooned during spring and summer tended to perform better in terms of ts/ha/month than those planted in autumn or ratooned during winter.

Table 7

Yield data and associated CV% values for five individual cane producers for the autumn plant*1 summer growth cycle (PA*1S)

Grower	No. fields	Area (ha)	Age		tc/ha		tc/ha/mth		ts/ha		ts/ha/mth		Sucrose	
			Mean	CV %	Mean	CV %	Mean	CV %	Mean	CV %	Mean	CV %	Mean	CV %
A	4	8,4	20,2	2,4	103,8	6,0	5,2	6,3	15,2	7,8	0,76	6,8	14,7	3,6
B	3	15,9	16,5	11,7	86,0	18,0	5,4	28,7	11,5	18,9	0,71	24,0	13,4	9,2
C	6	46,3	17,5	10,5	88,8	18,2	5,2	25,5	11,8	16,9	0,69	25,4	13,3	3,8
D	5	12,7	19,0	6,9	105,6	8,2	5,6	8,1	13,7	11,5	0,72	9,2	13,0	6,6
E	6	26,8	19,1	6,1	65,0	16,0	3,4	17,7	8,3	19,2	0,44	20,0	12,8	5,3

Despite the variability that exists within each growth cycle, the data in Table 6 indicate that yield differences can be detected for the different growth cycles. Using the 95% confidence limits the following interpretation can be made:

- tc/ha yields — comparisons
  - Positive responses : 1, 3, 4, 5, 7
  - Similar to positive response : 6
  - No response : 2, 9
  - Negative response : 8, 10
- ts/ha/month yields
  - Positive responses : 6, 7
  - Similar to positive response : 2, 3, 8, 9
  - No response : 1, 4, 5
  - Negative response : 10

These responses apply only to the season under review, which favoured the harvesting of younger cane. In the case of comparison 8 only was there any indication that younger cane could outyield older cane in ts/ha/month. The fields involved in the PS - S * 1S cycle need to be defined more precisely, in terms of slope position and soil type, as it is likely that these were fields of greater potential. An economic analysis also would be required to establish whether or not the increased yield was sufficient to cover the costs of the more frequent harvesting that would be involved.

Data variability

It appears that the yield differences between growers (Table 7) is making the largest contribution to the variability found in the data. It is essential that the reasons for these differences be identified if the overall productivity of the district is to be improved. The crop growth model which includes the interaction between weather, soils and crop growth should assist in identifying these reasons.

Conclusions

The computer software which has been developed to store, extract and manipulate FRS data has widened the scope and flexibility for the analysis and interpretation of these data.

The introduction of some statistical analyses has enabled valid comparisons to be made between different treatments, and assist growers and extension officers to make reliable management decisions. Yield differences between cane producers and within individual cane producers' farms have been identified as a major factor contributing to the variability found in the data.

The growth cycle comparisons made using the computer facility described, indicate that the variety N12 should be harvested on a two year cycle. Under these conditions the fields which regenerate during the spring/summer period are likely to produce higher sucrose yields that those which regenerate during winter.

Under certain conditions, which still have to be identified, N12, which regenerates during spring and is harvested 12-15 months later, could produce more sucrose than a two year crop which regenerates during winter. It appears that spring planted N12 with a two year growth cycle will be superior to autumn planted N12 grown through one or two summer periods. Where it is necessary to plant in autumn, the data indicate that the yield in ts/ha/month will be only marginally greater when the crop is grown for two summers instead of one.

FRS is a collection of yield data which represents what has occurred under field conditions, which can assist in the location of problem areas in cane productivity using these data. The crop growth model must also be used with FRS data to find the causes and solutions to these problems.

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