USING FRS TO PROVIDE ADVICE TO GROWERS ON THE OPTIMUM CANE AGE AT HARVEST IN THE MIDLANDS SOUTH AREA

By D. B. HELLMANN

South African Sugar Association Experiment Station, Private Bag X02, Mount Edgecombe 4300

Abstract

With the threat of eldana stem borer levels increasing in the midlands south area, and because older cane is more susceptible to eldana damage, there is a need to reduce the maximum age at which cane should be harvested, or to establish the maximum area of the farm that should be harvested in this area in any one season while providing a millable crop. The monthly cutting cycles required for harvesting varying percentages of the farm each season are presented. Yield data from the Industrial Field Record System (FRS) from 1980 to 1986 are used to establish the relationship between yield and rainfall for each monthly cutting cycle. Rainfall data from the Powerscourt and Beaumont meteorological stations are used to calculate the maximum area that should be harvested in this area in one season. The suitability of FRS data to establish general guidelines is also discussed.

Introduction

Eldana stem borer was first recorded near Eston during the 1985-86 season. Since then the incidence of eldana in the area has spread considerably and eldana moths have been captured in light-traps situated at Baynesfield and Richmond. Fortunately, except for a few isolated cases, eldana numbers have remained at relatively low levels. The combined Illovo/Natal Estates Local Pest and Disease Control (LP&DC) Committee has stipulated that the maximum age at which cane may be harvested is 24 months. The need exists, however, to establish more precisely what the maximum age of cane at harvest should be for the area if eldana levels were to increase markedly.

Considerable yield data have been collected from growers participating in the Industrial Field Record System (FRS) which was initiated by the SASA Experiment Station in 1978 and which is now run by the South African Sugar Industry Central Board (SICB).

Culverwell[1], Hulbert and Harding[2], and Tucker[4] have demonstrated the advantages of analysing commercial yield data and using this information either to assess productivity on individual farms or to make comparisons between homogeneous areas. It was decided to investigate whether the data from the FRS could be used to establish guidelines for a reduced maximum age of cane at harvest for the midlands south area.

Data submitted by 14 participants in the FRS were used in this investigation. The participants were drawn from the Eston, Mid-Illovo, Umlaas Road, and Powerscourt areas of the district: Growing conditions, with regard to rainfall and soil type, vary considerably between the different areas. Data for the 1981/82 to 1986/87 period were used.

Procedure

Establishment of cutting cycles

In order to determine for each month of the cutting season the cane age at the time of harvest, when various percentages of the area under cane were to be harvested, a number of assumptions had to be made:

- length of milling season: 9 months (April to December)
- one field harvested per month, ie 9 per season
- one field ploughed per season
- fields to be ploughed out would be harvested in April and re-established in October, ie 6-month fallow period
- harvesting sequence is oldest cane first

The different cutting cycles required to harvest from 50 to 75% of the area under cane annually are presented in Table 1.

Table 1

Age of cane (months) at harvest for each month of the cutting season in order to harvest specific percentages of the area under cane

% area harvested annually	50,0	52,9	56,3	60,0	64,3	69,2	75,0
Month of harvest	Age of cane (months) at harvest						
April	23	22	21	20	19	18	17
May	23	22	21	20	19	18	17
June	23	22	21	20	20	20	20
July	23	22	21	21	20	19	14
August	23	22	22	21	20	15	14
September	23	23	22	21	16	15	14
October	23	23	22	17	16	15	14
November	23	23	18	17	16	15	14
December	26	19	18	17	16	15	14
Mean age of cane harvested	23,3	22,0	20,6	19,3	18,0	16,7	15,3

Should any of the assumptions be altered, a different set of cutting cycles would be obtained. Possible changes could be

- October planting changes to March planting
- valley bottom fields harvested annually
- harvesting young cane during the peak sucrose period and completing the season with more mature cane.

It is acknowledged that, in practice, it may not be possible for many reasons, eg accidental fires, disease incidence, to adhere to the specified programmes.

Relationship between tc ha^{-1} and rainfall

From the FRS records the data for tc ha^{-1}, total rainfall and tc ha^{-1} 100^{-1} mm rainfall were determined for each age of cane and month of harvest shown in Table 1.

Because in some instances only a few fields of a given age had been harvested in a particular month, it was decided to combine the various combinations of age of crop and month of harvest into 4 broad crop cycles. The cycles are defined in Table 2.

Table 2

Grouping of harvest age and harvest month according to different summer (S)/winter (W) cycles

Cycle 1: W-S-W/S		Cycle 2: S-W-S/W	
Age at Harvest (mths)	Harvest month	Age at harvest (mths)	Harvest month
14	7, 8, 9, 10	14	11, 12
15	8, 9, 10, 11	15	12
16	9, 10, 11, 12	17	4, 5
17	10, 11, 12	18	4, 5
18	11, 12	19	4, 5, 7
19	12		
Cycle 3: W-S-W-S/W		**Cycle 4: S-W-S-W/S**	
Age at harvest (mths)	Harvest month	Age at harvest (mths)	Harvest month
20	4	20	5, 6, 7, 8
21	4, 5	21	6, 7, 8, 9
22	4, 5, 6	22	7, 8, 9, 10
23	4, 5, 6, 7	23	8, 9, 10, 11
		26	12

W = Winter start: May, June, July, August
S = Summer start: September, October, November, December
W/S = Winter, or following summer harvest
S/W = Summer, or following winter harvest

The variability of the relationship between tc ha^{-1} and rainfall is illustrated for Cycle 4 in Figure 1.

Nevertheless, for each cycle the mean values and standard errors for rainfall, tc ha^{-1}, and tc ha^{-1} 100^{-1} mm rainfall were determined for use in subsequent calculations. The mean values and standard errors obtained are presented in Table 3. The value of 6,28 tc ha^{-1} 100^{-1} mm rainfall for Cycle 3 is markedly lower than the values for Cycles 1, 2 and 4. This may or may not reflect a real difference between Cycle 3 and the other cycles, but it should be noted that it has a significant effect on the results of subsequent calculations.

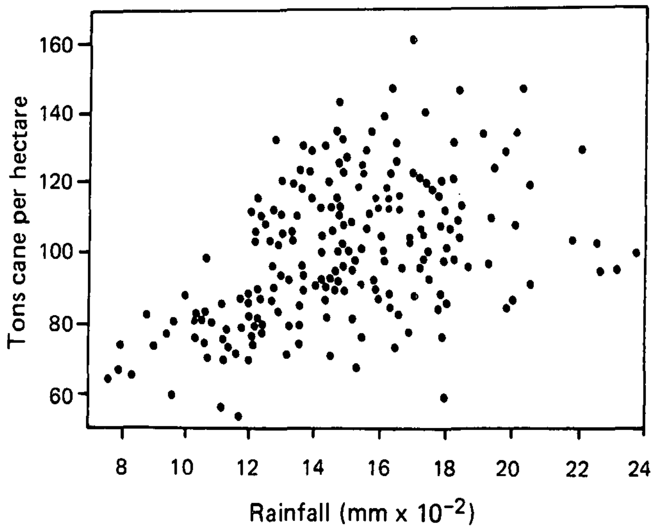

FIGURE 1 The relationship between tc ha^{-1} and rainfall for crops regenerating in summer and growing through a full winter and summer before being harvested again (Cycle 4).

Table 3

Mean values and standard errors (SE) for rain, tc ha^{-1}, and tc ha^{-1} 100^{-1} mm rainfall for the 4 cycles

Cycle	No of observations	Rainfall (mm)		tc ha^{-1}		tc ha^{-1} 100^{-1} mm	
		Mean	SE	Mean	SE	Mean	SE
1	117	1 130,4	254,9	75,5	17,1	6,82	1,47
2	89	1 355,2	300,7	89,0	19,5	6,76	1,63
3	95	1 573,7	255,3	97,1	19,5	6,28	1,38
4	201	1 481,7	311,3	99,0	19,5	6,84	1,37

Table 4

Mean rainfall and standard error (SE) for cycles ranging from 14 to 24 months for each month of harvest; Beaumont meteorological station (mean annual rainfall 741 mm; latitude 29°53', longitude 30°32', altitude 732 m). Data from 1963 to 1987

Month of harvest		Rainfall cycles (months)										
		14	15	16	17	18	19	20	21	22	23	24
Apr	Mean	909	1020	1109	1148	1275	1322	1351	1370	1385	1411	1458
	SE	157	172	177	185	190	196	195	194	205	207	206
May	Mean	865	955	1067	1157	1238	1322	1370	1399	1417	1433	1458
	SE	136	155	169	175	184	191	194	194	193	205	208
Jun	Mean	801	891	981	1093	1184	1265	1349	1397	1426	1444	1460
	SE	148	143	158	169	176	184	192	195	193	192	204
Jul	Mean	770	817	908	998	1109	1201	1281	1366	1414	1443	1461
	SE	148	151	145	160	171	176	183	190	193	190	192
Aug	Mean	764	789	836	926	1016	1128	1215	1296	1380	1428	1457
	SE	152	152	153	149	161	172	177	183	191	194	191
Sep	Mean	779	795	819	886	956	1046	1158	1247	1327	1412	1460
	SE	147	153	152	155	149	162	169	174	179	188	189
Oct	Mean	821	840	855	880	927	1017	1107	1219	1309	1390	1474
	SE	146	143	150	148	148	143	153	159	171	177	194
Nov	Mean	878	908	926	941	966	1013	1103	1193	1305	1396	1476
	SE	153	156	155	161	157	158	153	165	175	183	189
Dec	Mean	914	961	990	1008	1024	1048	1095	1186	1276	1388	1480
	SE	152	157	160	158	165	162	162	156	167	175	185

Rainfall data

The mean rainfall for each of the individual monthly cutting cycles presented in Table 1 was calculated from 24 years of rainfall records obtained from the Beaumont meteorological station (mean annual rainfall 741 mm, latitude 29°53', longitude 30°32', altitude 732 m). The mean values and the corresponding standard errors are presented in Table 4.

Results

Mean yields

The estimated mean yield (tc ha^{-1}) for each month of harvest and for each of the cutting cycles under investigation, was calculated by selecting the appropriate tc ha^{-1} 100^{-1} mm value from Table 3, and multiplying this value by the corresponding rainfall figure in Table 4. For example, a 20-month old crop harvested in August belongs to Cycle 4, and 6,84 tc ha^{-1} 100^{-1} mm should therefore be multiplied by $\frac{1\,215}{100}$ (from Table 4) to give 83 tc ha^{-1}. The predicted mean yields (tc ha^{-1}) are presented in Table 5.

Table 5

Predicted minimum yields in tc ha^{-1} for each month of harvest for different cutting cycles in the Beaumont area

Month of harvest	% Harvested						
	50,0	52,9	56,3	60,0	64,3	69,2	75,0
	Mean age of cane (months)						
	23,3	22,0	20,6	19,3	18,0	16,7	15,3
	Yield (tc ha^{-1})						
Apr	51	50	50	49	50	48	42
May	52	52	52	57	50	46	43
Jun	54	53	58	56	56	56	56
Jul	54	59	57	57	53	45	28
Aug	60	57	57	54	50	29	28
Sept	59	59	55	52	30	29	29
Oct	59	59	55	34	32	32	31
Nov	59	59	37	36	36	35	31
Dec	70	41	40	39	38	35	33
Mean tc ha^{-1}	58	54	51	48	44	39	36

Minimum yields

Assuming a normal distribution, the low value above which 90% of events occur is the mean less 1,3 times the standard error. Thus for tc ha^{-1} 100^{-1} mm rainfall (Table 3), the calculation: mean tc ha^{-1} 100^{-1} mm − (SE × 1,3) would give the minimum yield which should be exceeded in 90% of fields harvested. Similarly the minimum rainfall that should be obtained in 9 out of 10 years can be determined from Table 4.

From these minimum tc ha^{-1} 100^{-1} mm rainfall and minimum rainfall figures, and by the procedure explained for calculating the mean tc ha^{-1} yield, the predicted minimum yields in tc ha^{-1} were determined. These yields are presented in Table 6 and represent the minimum yields in tc ha^{-1} that could be expected from most of the fields harvested in most seasons.

Annual tons cane production

The yields of tc ha^{-1} for each of the cutting cycles (Tables 5 & 6) were then used to calculate the total tons cane produced per cycle per annum as well as the yields of tc ha^{-1}. In order to make comparisons between the cycles the total farm sizes have to be the same for each cycle. If for the 50% cutting cycle the 18 fields represent 18 ha, then for the other cutting cycles the number of fields pertaining to each cycle (Table 7) must also represent a total of 18 ha, ie each field will then be greater than 1 ha and the total yield data must be modified accordingly. The annual tc production figures determined are presented in Table 7.

Table 6

Predicted minimum yields in tc ha^{-1} for each month of harvest for different cutting cycles in the Beaumont area

Month of harvest	% Harvested						
	50,0	52,9	56,3	60,0	64,3	69,2	75,0
	Mean age of cane (months)						
	23,3	22,0	20,6	19,3	18,0	16,7	15,3
	Yield (tc ha^{-1})						
Apr	51	50	50	49	50	48	42
May	52	52	52	57	50	46	43
Jun	54	53	58	56	56	56	56
Jul	54	59	57	57	53	45	28
Aug	60	57	57	54	50	29	28
Sept	59	59	55	52	30	29	29
Oct	59	59	55	34	32	32	31
Nov	59	59	37	36	36	35	31
Dec	70	41	40	39	38	35	33
Mean tc ha^{-1}	58	54	51	48	44	39	36

Table 7

Predicted mean and minimum total tons cane for the season and yields in tc ha^{-1} a^{-1} based on the Beaumont meteorological station data

% Harvest annually	50,0	52,9	56,3	60,0	64,3	69,2	75,0
Mean cane age (mths) for the season	23,3	22,0	20,6	19,3	18,0	16,7	15,3
No fields under cane	18	17	16	15	14	13	12
Area correction factor	1,00	1,06	1,13	1,20	1,29	1,38	1,50
Total tca^{-1}	858	864	875	877	884	876	874
Total minimum tca^{-1}	518	518	521	520	510	490	482
Mean tc ha^{-1} a^{-1}	47,7	48,0	48,6	48,7	49,1	48,6	48,6
Minimum tc ha^{-1} a^{-1}	28,8	28,8	28,9	28,9	28,3	27,2	26,8

Discussion

Cane yield was used for this investigation as it was felt that the relationship between cane yield and rainfall was better understood than the one between sucrose yield and rainfall.

It must be pointed out that the conclusions drawn from the data presented apply only to the area from which the yield data were obtained and for the period during which the data were collected. A move to higher yielding varieties and any major change in the rainfall pattern would present a different set of yield data from which different conclusions could be drawn.

Care must be taken when interpreting the data as the yield values that have been presented are mean yields, determined from a wide range of conditions which include factors such as rainfall, soil type, soil depth, varieties, crop status (plant to successive ratoons) and management. Where conditions are more favourable, the more conservative the conclusions will be, and vice versa.

The tc ha^{-1} 100^{-1} mm rainfall yields presented in Table 3 are considerably less than would be expected from the yield: evapotranspiration (E_t) relationship determined by Thompson[3]. This relationship took the form of the following linear regression equation:

$$\text{tc ha}^{-1} = 9{,}69\ (E_t \text{ mm} \div 100) - 2{,}4$$

This relationship was, however, established using effective water, while total rainfall was used to determine the tc ha^{-1} 100^{-1} mm yield data presented in this study.

Maximum age at which cane should be harvested in eldana areas

If it is necessary to reduce the age of cane at harvest in order to reduce eldana numbers, cane yield becomes a primary consideration. It is also necessary to establish the age at which cane is likely to be harvestable when unfavourable conditions prevail, ie low rainfall and low yields.

The data presented in Table 6 can be used to assess the maximum age of cane at harvest that can be recommended for the area from which the data were collected. A decision has to be made as to what can be regarded as the minimum millable cane yield. For the purposes of this study, this yield has been taken to be 40 tc ha^{-1}.

From Table 6, it can be seen that harvesting 52,9% of the area under cane should produce a yield of 40 tc ha^{-1} or more. This represents a mean age of cane at harvest of 22 months and a maximum age of 23 months (Table 1).

Age at harvest in relation to annual production

In order to determine the optimum age of cane at harvest to obtain the maximum profit, it would be necessary to examine sucrose yields and not cane yields. It is however interesting to note the trends in the cane yields obtained for the various cutting cycles.

The data presented in Table 7 indicate that under average rainfall conditions, the maximum tc ha^{-1} yield is obtained when 64,3% of the area under cane is harvested annually. The optimum mean age at harvest, in terms of cane yield, is therefore 18 months. The yield per annum declined when the area harvested per annum was increased.

High rainfall conditions

The same exercise was done with rainfall data from the Powerscourt meteorological station (mean annual rainfall 976 mm, latitude 29°58′, longitude 30°38′, and altitude 631 m). It was found that under conditions of higher rainfall, the average age at which the crop could be harvested was lower than that determined from the Beaumont rainfall data.

Under unfavourable conditions of rainfall and cane production, a mean cane age of 18 months would be recommended (maximum age of cane at harvest 20 months or 64,3% of the area under cane harvested annually).

To maximise tc ha^{-1} production, a mean cane age at harvest of 18 months would be recommended when rainfall and growth conditions are average. Under unfavourable conditions, maximum cane production per annum would be achieved with a cane age at harvest of 20,6 months.

Suitability of using FRS data

This investigation has shown that if the FRS data are to be used in an attempt to formulate general guidelines or recommendations, a major problem is the wide variability that exists in the data (Figure 1). To at least some extent this variability represents natural field conditions and they need to be taken into consideration when interpreting the data.

At present the system can only create crop summaries for each single variable (eg variety, crop age, soil type) or interaction tables where only two variables can be investigated (eg crop age in relation to harvest month). The result is that all the data stored in the system are included in an analysis. As the amount of data on record accumulates it should become feasible to be more selective. For this investigation, data were extracted in the form of 'harvest month in relation to harvest age' interaction tables. The yields in these tables had only these two factors in common; there was no way of identifying the other variables, such as variety, soil type, or crop status, that affected the data. The variability found in this study would no doubt have been reduced if more specific information could have been extracted. Ideally, the data required should have been extracted in the form of 'harvest age in relation to harvest month' yield data according to soil type (depth, clay content). Factors which could be considered exceptional could have been excluded. An example of this would apply to certain varieties. New varieties such as N12 would have contributed yield data that would have been greater than that produced by the bulk of the data which had been derived from varieties NCo376 and NCo293. Older varieties such as NCo382 would have produced lower yields.

The computer software necessary to improve the way in which the data can be extracted from the record system has recently become available, and it should be possible to manipulate the data stored in FRS in a more useful manner.

Conclusion

The exercise described in this paper was based on a limited accumulation of data, and it was carried out more to illustrate the usefulness of FRS records than to reach substantial conclusions. It is considered that it will become possible to use FRS records effectively to establish general guidelines for various agronomic practices relating to cane production

The variability of the data is to a large extent a result of actual field conditions, and must be borne in mind when guidelines are formulated. It is anticipated that, as the volume of stored data increases, improvements in the ability to extract and manipulate data from the stored FRS records will result in investigations of a more specific nature.

In the event of eldana numbers increasing in the midlands area, the limit to the maximum age of cane at harvest that could be recommended to ensure continued cane production is at this stage 20 months (64,3% of the area under cane harvested annually at an average age of 18 months) for the higher rainfall areas of the district, and 23 months (52,9% of the area under cane harvested annually at an average age of 22 months) for the lower rainfall areas.

If eldana were not a consideration, the cane yield data indicate that for conditions of average rainfall and yield, annual production would be greatest if 64,3% of the area under cane were harvested annually in both the wetter and drier areas. Under conditions of lower rainfall and lower yields, maximum annual production would be achieved by harvesting 56,3% of the area under cane.

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