SOME FACTORS AFFECTING FLOWERING IN SUGARCANE

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Abstract

Flower counts made in field experiments over six years led to the following conclusions: of the commercial varieties, N 52-219 and NCo 310 were the heaviest arrowers, NCo 376 and CP 29-116 were intermediate, and Co 462, M 31-45 and Co 1001 were shy arrowers. Flowering behaviour was assessed in 52 varieties.

In irrigation and drying off trials, wet treatments produced more flowers than dry treatments; the presence of a water table increased flowering. Nitrogen deficiency increased flowering substantially; urea produced somewhat more flowers than ammonium nitrate, and phosphate application appeared to reduce flowering. When the previous crop was burnt there appeared to be more flowering then when the previous crop was trashed.

Large annual fluctuations in flower counts could be accounted for by minimum temperatures and rainfall/sunshine hours during the inductive period. The "ripe to flower" condition occurred with cane of 2-2½ months age at induction, with some differences between varieties. There was a slight increase in flowering with cane of increasing age from 3-8 months at induction.

Introduction

Flowering is a very variable phenomenon in the Rhodesian Lowveld. There are large differences from year to year, from field to field and within fields. During the course of six years experimental work on numerous agronomic aspects of sugarcane culture, flower counts have been made regularly in all experiments. This has produced information on some factors affecting flowering, which is given below. In each case, several counts were made and the data selected represent the maximum number of flowers which emerged during the season.

It has been well established that floral initiation occurs when the day length is around 12½ hours (Coleman[3]). In our latitude (21°S) the photo-inductive period evidently occurs during the first three weeks in March. The flowers actually begin to emerge during May; the main period of emergence is June-July and the procedure is essentially complete by August, after which the flowers begin to die back. Floral initiation does not occur during the spring 12½ hour photoperiod, because of low temperatures and lengthening days.

Varieties

Tremendous differences in flowering behaviour were apparent between varieties; of the major varieties, NCo 310 has been the most prolific flowerer. Our main variety, NCo 376, flowers substantially less than NCo 310, but high counts have been obtained under certain conditions. As great variability occurs between experiments and years, all comparisons have been made on a percentage basis with NCo 376 taken as 100. Flower counts were made in 20 crops in 10 variety trials and the data have been meaned to give the results in Table 1.

TABLE I

Relative Flowering of Tested Varieties

(NCo 376 = 100)

B 42231	159	L 60-25	145	NCo 310	231
B 4362	0	L 61-43	125	NCo 376	100
B 47-419	0	L 61-67	142	Pindar	0
B 57-150	0	L 62-68	159	PR 980	0
CB 36-14	0	L 62-96	147	PR 999	0
CB 40-77	0	M 31-45	0	Q 57	0
Co 462	5	M 383-41	<1	Q 61	0
Co 678	<1	Mex 54-81	0	Q 63	0
Co 684	0	Mex 55-261	21	Q 68	0
Co 740	0	Mex 56-476	5	Q 70	0
Co 775	4	Mex 57-337	0	Q 71	0
Co 957	0	Mex 59-1828	0	Q 76	0
Co 1001	<1	Mex 60-1403	0	Q 80	0
CP 29-116	88	N 51-168	58	Q 85	0
CP 43-47	0	N 51-539	31	Ragnar	0
CoS 109	35	N 52-219	306	Waya	37
Ebene 1/37	0	N 55-805	258	Woden	0
F 146	1				

It can be seen that the recently released variety N 52-219 is in fact a heavier flowerer than NCo 310. The remaining commercial varieties are either moderate flowerers (CP 29-116), shy flowerer (Co 462) or produce essentially no flowers (Co 1001 and M 31-45).

The above data represent averages over a number of observations. However in individual instances, the position may be reversed e.g. in one trial NCo 376 produced more flowers (41 900/ha) than did NCo 310 (25 600). Varietal response to environmental factors causing floral induction is thus seen to differ over the seasons.

Soil moisture

The effect of high soil moisture content or a high water table on increasing flowering is well known, and it has been frequently observed that cane growing along feeder canals, or in other areas of high moisture, flowers more than in other areas. Conversely, poorly irrigated parts of fields flower much less.

Flower counts were made in an irrigation trial in 1969 (2nd ratoon) and 1972 (5th ratoon) and results are given in Table II. No flowers were observed in other years. The variety was NCo 376, and the experiment was cut each November.

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TABLE II

Effect of irrigation level on flowering

Pan factor	1969		1972	
	Water applied (mm)	Flowers per ha.	Water applied (mm)	Flowers per ha.
1,00	1 473	44	1 224	1 186
0,84	1 219	57	1 020	1 195
0,84/0,60*	1 118	22	867	1 263
0,68	914	7	714	1 241
0,53	660	12	510	880
0,37	457	5	306	620

*0,84 for first 8 months and 0,60 for last 4 months

There was a fairly consistent reduction in flowering with decreasing irrigation levels in 1969, but the reduction only occurred with the two driest levels in 1972. This was probably because there were good rains totalling 430 mm in January-March 1972, and only the two driest treatments suffered moisture stress during this time.

In a drying-off trial harvested in July each year, drying-off treatments were commenced in March. The effects of drying-off on 4th ratoon NCo 376 are given in Table III.

TABLE III

Effect of drying-off on flowering

Pan factor in:				No. of flowers/ha.
March	April	May	June	
1,0	1,0	1,0	1,0	10 163
1,0	1,0	0,67	0,67	7 122
0,67	0,67	0,67	0,67	6,225
0,67	0,67	0,5	0,5	7 095
0,5	0,5	0,5	0,5	4 646
0,5	0,5	0,4	0,4	4 709
		L.s.d. (5%)		3 703
		(1%)		5 121

Increasing intensity of drying-off caused a substantial reduction in the number of flowers produced.

Drying-off had no effect on flowering in two other trials. In one of these, harvesting took place in September with drying-off commencing in May, and in the other, harvesting took place in December with drying-off commencing in August.

It is therefore apparent that moisture stress during the crop (mainly during March) has resulted in substantial reduction in flowering.

Field observations indicate that flowering is increased in areas of perched water table and Inniss[7] successfully increased flowering by manipulating the water table. In a water table experiment carried out in drums, Gosnell[6] found high levels of flowering in NCo 310 in all water table treatments ranging from 25-125 cm in depth during 1968 and 1969. The intensity of flowering was much higher than in field grown cane during these two years; percentage flowering was between 60 and 80% in most treatments with a water table, compared with 1-8% flowering in NCo 310 in adjacent field experiments.

However, as shown in Table IV, maximum flowering did not occur with the shallowest water table, but where it was at a depth of 75-125 cm. This was probably due to the shallow water table causing poor growth and tillering in the 25 and 50 cm treatments.

TABLE IV

Effect of depth of water table on flowering

Depth of water table (cm)	1968		1969	
	No. of flowered stalks/drum	% of total stalks	No. of flowered stalks/drum	% of total stalks
25	7,8	43,3	2,0	10,6
50	13,4	62,0	12,2	48,0
75	18,2	72,8	17,0	58,6
100	19,4	82,9	20,4	69,9
125	18,4	73,6	19,2	67,1
L.s.d. 5%	4,0	—	3,9	—
C.V.%	18,1	—	20,0	—

During the third year of the trial (1970) no flowering occurred in any treatment. This was a year when cold nights during March inhibited flowering in all experiments (see Table X). It is therefore evident that a water table can only increase flowering when temperature is non-limiting.

Fertilizers

Nitrogen level

Increasing levels of nitrogen have consistently resulted in reduced amounts of flowering.

Results from two trials where six levels of N were applied to NCo 376 are given in Table V.

TABLE V

Effect of N level on flowering

Expt. 1 (Nov/Dec harvest)			Expt. 2 (Aug harvest)	
Level kg N/ha	No. of flowers/ha		Level kg N/ha	No. of flowers /ha 1972
	1969	1972		
0	3 969	3 138	0	12 479
34	1 867	3 605	40	8 940
67	948	2 569	80	4 154
101	408	2 350	120	4 137
134	431	2 175	160	4 581
168	104	2 175	200	4 479

There was evidently a marked reduction in flowering with increasing levels of nitrogen up to 80-100 kg

N/ha. Beyond this level, the reduction was not so marked and differed with varieties, being much more marked with NCo 310 than with NCo 376 and CP 29-116, as shown in Table VI.

TABLE VI
Effect of variety and N-level on flowering

kg N/ha	NCo 310	NCo 376	CP 29-116
101	10 947	2 907	7 493
140	9 414	2 031	5 790
179	8 101	1 995	3 089
218	6 495	2 579	3 381
258	5 084	1 265	3 929

An even more marked effect of nitrogen on flowering was observed with Co 1001, a variety which virtually never flowers in the Rhodesian Lowveld. It was found that nitrogen deficiency resulted in flowering in this variety, as shown in Table VII. This experiment was cut in November.

TABLE VII
Effect of nitrogen on flowering in Co 1001

Level of N in kg/ha	No. of flowers/ha
0	4 240
40	3 960
80	349
120	0
160	0
200	0

Nitrogen carrier

There is some evidence that the use of urea has resulted in more flowering than occurs when sulphate of ammonia or ammonium nitrate is used. It was noted previously by Gosnell[5] that urea caused significantly more flowers to develop (14 200/ha) than did sulphate of ammonia (9 500/ha) in NCo 310.

Comparisons of urea and ammonium nitrate in 1972 in two experiments also indicated that urea caused slightly more flowers to occur than did ammonium nitrate, as shown in Tables VIII and IX.

TABLE VIII
Effect of nitrogen carrier and variety on flowering

	No. of flowers per hectare	
Variety	Urea	Ammonium nitrate
NCo 310	8 276	7 741
NCo 376	2 608	1 703
CP 29-116	5 079	4 393
Mean	5 321	4 612

Phosphate

Phosphate application reduced flowering in one experiment, from 10 226/ha where no phosphate was applied, to 5 875/ha where 100 kg P_2O_5/ha was applied, with N 52-219, and from 288 to 154/ha with NCo 376. Although this effect was not quite significant at the 5% level, it was probably real, as results were similar over all six levels of drying-off which were compared in the same experiment.

Trash management

It appears that when the previous crop was burnt, cane produced a larger number of flowers (1 233/ha) than occurred when the previous crop was trashed (896/ha). This was consistent over both nitrogen carriers, as shown in Table IX.

TABLE IX
Effect of trash management and nitrogen carrier on flowering

Previous crop:	Urea	Ammonium nitrate	Mean
Burnt	1 417	1 049	1 233
Trashed	1 107	684	896
Mean	1 262	867	—

Soil type

Visual observation suggests that the most consistent and heaviest flowering in the Lowveld occurs on paragneiss-derived soils which have lateritic subsoil. The next most prolific are paragneiss P E 1 & P 1 series and areas of basalt soil with impeded drainage. Basalt soils with good drainage have less flowering while gravelly or sandy soils of the series P 2 and P 3 usually have the least flowering. It is believed that these variations can be directly attributed to soil moisture status; the soil with a perched water table having the highest amount of flowering, followed by soils with a good moisture holding capacity, while the soils with poor moisture holding capacity have the least flowering.

Seasonal variation

The effect of minimum temperatures during the photoinductive period has been well documented e.g. Clements & Awada[2], Paliatseas[8]. From the literature we would expect a good inverse correlation between the amount of flowering and the number of nights in the period 1-20 March when the minimum temperature drops below 18°C (64,4°F). Where this number is 10 or more, flowering would be expected to be severely inhibited. An attempt has been made to check this hypothesis over the six years 1967-72, using data from a single experiment which advanced from plant crop to 5th ratoon during the period. The data are total counts for 30 plots of NCo 310. Table X shows flower counts, minimum temperature data and rainfall and sunshine hours for the inductive period over the six years.

TABLE X

Effect of climate on annual fluctuation in flowering

Year	No. of flowers per ha (NCo 310)	No. of nights minimum temperature below 18°C 1-20 Mar.	Rainfall (mm) 15 Feb-16 Mar.	Mean daily sunshine hours 15 Feb-16 Mar.
1967	513	11	191	6,57
1968	1 287	3	23	7,92
1969	10 762	0	130	7,06
1970	0	9	23	9,53
1971	18	1	9	9,89
1972	4 504	5	88	6,75

There was very little or no flowering in those years (1967 and 1970) when the number of cold nights (minimum temperature below 18°C) was around 10. The small amount of flowering in 1967 may be related to the exceptionally wet and cloudy conditions that year.

However in the remaining years, there were evidently too few cold nights for temperature to be a controlling factor. The number of flowers each year appeared to be positively correlated with rainfall and negatively correlated with sunshine hours during the period 15 February to 16 March. In 1969 and 1972 when there was high rainfall and low sunshine hours, flowering was profuse while the dry sunny conditions of 1968 and 1971 resulted in relatively little flowering. It might be thought surprising that rainfall should affect flowering in an irrigated area. However, it is believed that the rain enabled large areas of cane to remain close to field capacity while substantially greater moisture tensions would have developed in other years when rainfall was low. It has also been reported by Davies & Vlitos[4] and Burr *et al*[1] that cloudy weather over the induction period promotes floral initiation, while sunny dry weather tends to inhibit it.

Using temperature, rainfall and sunshine data, it should thus be possible to predict the amount o flowering each year by the end of March.

Age

Cane must be of a certain minimum physiological age before it is large enough to be affected by the flowering stimulus. This "ripe to flower" condition occurs at about 2-3 months or after about 3 nodes have formed on the stalk (Davies & Vlitos[4]). With older cane, the flowering stimulus is almost independent of age. However in one experiment where cane was cut in May, July, September or November 1971, (around the 15th of each month) it was found that increasing age between 4 and 8 months resulted in slightly increasing amount of flowering. This is indicated in Table XI which gives data meaned for NCo 310 and NCo 376 over a total of 66 plots.

TABLE XI

Effect of age on flowering (mean NCo 310 & NCo 376)

Month cut	Age on 15 March (months)	Flowers per ha.
May 1971	10	33 182
July 1971	8	34 608
September 1971	6	27 797
November 1971	4	23 149

Varieties may differ slightly in their minimum age requirement before the "ripeness to flower" condition is fulfilled. Observations during the 1971/72 season indicated that with N 52-219, flowering occurred in fields which had been cut in December (or earlier) and right up to the first few days in January. Fields cut after this did not flower. With NCo 376, however, observations have indicated that fields cut after 15-20th December did not flower in 1972.

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