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QUANTITATIVE ASSESSMENT OF FLOWERING BEHAVIOUR IN SUGARCANE

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Abstract

Relationship between flowering behaviour and sugar yields was investigated in 48 local and exotic sugarcane accessions grown in replicated trials over four cropping stages in a typical Guinea Savannah ecology. Significant genotypic differences were observed among the flowering (F) clones for all parameters investigated while the nonflowering (NF) clones differed only for cane yield, sucrose content and millable cane population/plot.

Trend in productivity of clones revealed that there was no relationship between either period or extent of flowering and cane yield as some of the clones which flowered profusely yielded significantly higher than sparsely flowering clones regardless of the period of flowering.

Differences in cane yield between F and NF clones were 0.4, 3.24, 0.64 and 4.08 t/ha respectively in each of the harvest stages while differences in sucrose content were negligible. However, much of the observed variability for cane yield was due to the F clones with the mid and late flowering types contributing 43.4 and 42.7 percent respectively. Thus, genes for high cane yield in these two sub-groups could be introgressed in to future varieties.

Introduction

The aspects of flowering in sugarcane (*Saccharum officinarum* L.) has been thoroughly investigated by several workers. Such studies which include relationship between flowering and other characters (Nour *et al.*, 1980), yield loss associated with flowering in such varieties (Arconoaux, 1965; Evans, 1966; Paje *et al.*, 1969; Oworu; 1987) and methods of ar[1]tificial control of flowering with their yield advantages (El-manhalay *et al*, 1984; Moore and Osgood, 1986; Fadayomi *et al*; 1995) are well documented.

Underlying most of these discussions is that the onset of floral initiation leads to (i)ceasation of terminal bud growth and so biomass

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accumulation, (ii) diversion of photoassimilates from sucrose accumulation to flower/seed production and (iii) reduction in cane yield with poor sucrose quality occasioned by delay in harvesting of such varieties.

For example in Nigeria, loss in sugar yields of 3.4% (in B63118 at 30% flowering) and 2.5% (in C0440 at 50% flowering) was reported by Oworu (1987). The author further noted a significant reduction in cane weight, brix content but higher fibre content in flowering (F) stalks relative to nonflowering (NF) stalks of same age in both varieties. Fadayomi *et al.* (1995) used ethephon (a growth regulating chemical) to control flowering in three (3) commercial varieties (Co 997, CB 53/98, CP 29/116). The authors reported an overall yield advantage of 14 and 20% respectively in Co 997 and CB 53/98 but a 30% yield reduction in CP 29/116.

While these studies and those of others elsewhere have provided information on the relative advantage of either controlling flowering in F varieties or immediate harvesting of such varieties, there is yet no information on the extent of yield loss associated with different periods of flowering. Such information if available, will likely assist growers in planning their reaping schedule without fear of incurring economic loss. This study was therefore initiated to provide detailed information on the relationship between flowering behaviour and sugar yields. Since to a sugarcane breeder, flowering is desired for development of newer and more productive varieties, information obtained there in will also be useful in effecting crossing between productive F varieties of different flowering behaviour especially under natural conditions.

Materials and Methods:

The data used in this study were part of some quantitative and qualitative parameters collected from 48 foreign and adapted sugarcane clones which differed in their flowering behaviour (Table 1). The clones were grown in a two - replicate randomized complete block design at the University of Ilorin Sugar Research Institute's experimental farm. Each clone was planted in to two-row plots 5m long and 1.65m between the rows. Cultural practices (fertilizer application, weed control, etc) were carried out each year as necessary. The plots received supplemental irrigation during the dry season (November - April) of 1991/92 and for another four weeks after the plant cane was harvested in order to ensure proper stand re-establishment.

The data collected over a four-year period included days to floral initiation, flagging, tipping; first arrow (flower) emergence and 50% arrow emergence. Other data collected included number of stalks/stool, millable cane population/plot, number of internodes/stalk, length of

internode, stalk length, stalk diameter, brix (an estimate of sucrose in the juice) and cane yield. Apart from arrowing data and cane yield which were on whole-plot basis, other data were collected from 10 random stalks/plot while stalks/stool was based on five competitive stools in a plot. Cane yield was first obtained in kg/plot but was later converted to tonnes/ha. On the basis of 50% arrowing, the F clones were grouped into early flowering (EF) mid-flowering (MF) and late flowering (LF) respectively. Since studies (Smith and James, 1969; Kang *et al.*, 1983; Chapman, 1988) have shown that brix tend to increase as from the first ratoon crop such that genotypic differences can be detected from that cropping stage, data on sucrose accumulation at each of the arrowing stages were collected by sampling brix content from the middle of 10 stalks of similar age in a plot. The age of a stalk was determined by counting the number of internodes as soon as floral initiation commenced in the F clones.

Table 1: List of sugarcane accessions indicating their flowering behaviour.

Non flowering	Early Flowering	Mid-Flowering	Late Flowering
LSI –058	BR 6223 (P) +	B69620 (P)	DB 95/57 (P)
LSI – 084	BJ 6552 (P)	B5992 (P)	B6604 (P)
LSI – 086	BJ 6547 (S)	Co 440 (P)	LSI – 085 (S)
B 5715	Co 396 (S)	Co 1001 (S)	LSI – 057 (P)
B4681	Co 443 (S)	Co 404 (S)	
B 61208	Co 691 (P)		
Co 957	Co 453 (P)	Co 6806 (P)	
Co 976	Co 449 (S)	Cp 36 /111 (P)	
Co 997	CP 29/116 (P)	Dacca (P)	
D 47/15	DB 20/58 (S)	IAC 48/65 (P)	
DB 51/55	LSI – 027(S)	LSI – 029 (P)	
	LSI – 033 (S)	LSI – 028 (P)	
	LSI – 083 (P)	LSI – 019 (P)	
	LSI – 087 (P)	LSI – 031 (P)	
	LSI – 047 (S)	LSI – 026 (P)	
	MEX 52/29 (P)	LSI – 054 (P)	
		LSI – 050 (P)	
		LSI – 098 (P)	

P = Profuse: S = Shy/sparse.

In order to obtain information on the period and extent of sucrose decline in the F clones, brix readings were obtained over a 10-week period immediately following 50% arrowing from the same 10 selected stalks in each of the F variety. Similar brix readings were obtained from the NF clones of similar age with the F clones.

Data collected for F and NF clones were analysed first on individual crop basis. The data for individual crops were then pooled over cropping stages before a combined analyses of variance (ANOVA) was performed.

Results and Discussion

Results from the combined ANOVA for both F and NF clones are presented in Table 2. Differences among the harvest stages (HS) were significant ($P \leq 0.01$) for all the characters in both F and NF clones and this may be an indication of differences in vigour which tends to decline with age in sugarcane (Ricand and Arceneaux, 1986). The differences may also be related to the level of soil moisture which varied in each year of study since the trial was conducted under rainfed condition. Genotypic (G) and GXHS interactions were also significant ($P \leq 0.05$ or 0.01) for all characters in the F clones. Conversely, the NF clones differed ($P \leq 0.05$ or 0.01) only for cane yield, brix %, millable cane population and internode length. While the significant genotypic differences in both F and NF groups suggests the existence of variability for these characters, the significant GXHS interaction in the F clones is an indication of differences in performances of the genotypes in each of the cropping stages. Differences may also result from the fact that missing gaps (which were higher in F clones due to death of flowered stalks) were not supplied throughout the duration of this study.

Although many of the F clones were higher yielding than the NF clones, comparison between the F and NF clones (Table 3) revealed a significantly lower mean yield in the former especially in the plant and third ratoon crops as well as in sucrose content in all the crops. For example, differences in cane yield between F and NF clones were 0.4, 3.24, 0.64 and 4.08 t/ha respectively in each of the cropping stages. The same trend was observed for most of the yield components and this may be responsible for differences in yield between the two groups. The results obtained in this study compares favourably with the findings of Oworu (1987) who observed that flowering stalks of same age in Co 440 and B 63118 had lower cane weight and less brix % than their NF counterparts.

Comparison among the F clones (Table 4) showed that the LF genotypes had higher sucrose content than either EF or MF genotypes. However there was no definite trend among each of the sub-groups with respect to cane yield. For example, the LF clones yielded significantly higher than the MF or EF genotypes in the plant and second ratoon crops while the EF clones were superior to both MF and LF in the third ratoon crops. Oworu (1987) postulated that differences in sugarcane varieties in loss of total brix resulting from flowering may be attributed to

time of flowering, extent of pithiness and pattern of side shooting. In other words, EF clones are expected to suffer greater yield than MF or LF clones. Results obtained in this study especially in respect of brix content supports this hypothesis.

Sucrose in the juice showed a decline especially in the third ratoon crop (Table 5). In each of the harvest stages and beginning from floral initiation, there was a gradual decline in sucrose accumulation. However, the decline was most noticeable between flagging/tipping and tipping/arrow emergence. This suggests that the best time for harvesting F varieties is between tipping and arrow emergence to avoid loss in sugar yields.

Although differences in sucrose accumulation over a 10-week period following 50% arrow emergence did not differ significantly among the sub groups (Fig. 1), the NF had the highest mean sucrose content. Values obtained showed that sucrose accumulation in the NF varieties continued until the fifth week of sampling. Conversely, decline in sucrose content was observed in the F clones from the second week after 50% arrowing irrespective of the period of flowering. Except for few fluctuations in brix reading (which is likely due to sampling error), the decline in each of the sub-groups was steady until the final harvest was carried out.

The trend in the productivity or selected genotypes among the F clones indicated that there is no relationship between either period or extent of flowering and sugar yields (Table 6). For example, variety MEX 52/29 (Early & profuse flowering) was consistent with respect to cane yield in subsequent ratoon crops compared to others. Similarly, varieties which flowered profusely performed better than sparsely flowering clones regardless of the period of flowering. This suggests that yielding ability in sugarcane is genotype dependent and is not influenced by period and / or extent of flowering. The decline in sucrose content in the third ratoon crop may be due to the fact that harvesting was delayed to monitor the rate of decline in sucrose content for a 10 week period after 50% arrowing. This may also be responsible for the low cane weight recorded in the third ratoon crop relative to pervious ratoon crops.

Average days to each of the flowering stages appeared relatively constant over a four year period (Table 5) indicating that the process is not dependent on weather factors. The intervals between the critical period for effecting crosses (Table 5) were 8 - 10 days (floral initiation/flagging) and approximately 12 days/flagging/tipping). This information is particularly useful to sugarcane breeders in planning hybridisation programme intended to synchronise flowering either for EF x MF, EF x LF, MF x LF crosses in the field by delayed planting of the earlier flowering parent. When the genotypic effect for cane yield were

Table 2: Mean squares from the combined analyses of variance (AOV) for cane yield and yield componets of Non-flowering and flowering (in parenthesis) sugarcane accessions.

Source	df	Cane yield 10^3	Brix 10^2	Stalks/ stool 10^2	Millable cane 10^4	Stalk length	Stalk Diameter 10^2	No of internodes 10^2	Length of internode
Harvest									
Stage (HS)	3	3.70**	1.66*	0.83**	7.80**	2.62**	45.54**	2.80**	5.82
		(15.0**)	(2.87**)	23.31**	(23.31**)	13.29**	(10.20**)	(7.76**)	(28.41**)
Rep/HS	4	0.06	0.02	0.003	0.07	0.205	0.001	0.08	(5.54
		(0.03)	(0.04)	(0.13)	(0.25)	(0.25)	(0.006)	(0.02)	(5.03
Genotype (G)	10	0.70**	0.10*	0.018	0.60**	0.159	0.001	0.08	12.48**
	36	(0.20**)	(0.05**)	(0.13**)	(0.24**)	(3.18**)	(0.006**)	(0.07)	(13.18**)
GXHS	30	0.08	0.05	0.08	0.07**	0.112	0.002	0.10	6.86
	(108)	(0.16**)	(0.05**)	(0.14**)	(0.13**)	(0.16**)	(0.001**)	(0.12**)	(3.83**)
Pooled									
Error	40	0.06	0.04	0.01	0.09	0.021	0.0005	0.06	3.71
	(144)	(0.06)	(0.03)	(0.06)	(0.06)	(0.10)	(0.0008)	(0.08)	(2.60)

*, **, Significant at 0.05 and 0.01levels of probability respectively.

Table 3: Mean cane yield and yield components of flowering and non-flowering sugarcane accession.

Trait	Plant crop		1st Ratoon		2nd Ratoon		3rd Ratoon	
	FL	NF	FL	NF	FL	NF	FL	NF
Cane yield (tha)	43.58 (14.95)	43.98 (12.42)	19.04 (4.30)	22.28 (8.01)	19.69 (12.7)	20.33 (15.02)	10.43 (7.07)	14.51 (10.62)
Brix	16.74 (2.13)	16.55 (2.69)	20.08 (1.89)	20.82 (2.11)	17.88 (1.11)	18.64 (1.47)	15.43 (2.21)	15.68 (2.57)
Stalk/stool	10.61 (2.13)	11.32 (2.48)	13.87 (2.82)	15.36 (2.85)	10.28 (1.93)	11.68 (2.87)	9.83 (4.79)	11.46 (4.23)
Millable canes	112.30 (16.24)	114.09 (24.61)	169.66 (44.17)	179.23 (55.37)	69.01 (35.64)	76.09 (33.80)	40.81 (32.76)	40.14 (26.32)
Stalk length (m)	1.94 (0.37)	1.87 (0.48)	1.26 (0.35)	1.25 (0.29)	1.27 (0.34)	1.28 (0.23)	0.93 (0.38)	1.08 (0.25)
Stalk diameter (cm)	3.08 (0.37)	3.09 (0.29)	2.15 (0.39)	2.36 (0.31)	2.24 (0.21)	2.16 (0.17)	2.10 (0.28)	2.10 (0.19)
No of internode	19.30 (3.76)	19.64 (3.70)	13.51 (3.31)	14.27 (3.41)	12.03 (2.01)	12.46 (1.47)	13.34 (2.81)	14.68 (2.98)
Length of internode (cm)	11.85 (2.02)	10.92 (2.59)	10.80 (1.59)	10.36 (2.21)	12.26 (1.84)	11.55 (3.03)	13.34 (2.81)	11.29 (2.98)

FL = Flowering, NF = Non Flowering. Figures in parenthesis is the standard error of the mean.

Table 4: Mean cane yield and yield components of early, mid and late flowering sugar cane accessions.

	Plant Crop			Fist Ratoon			Second Ratoon			Third Ratoon		
	EF	MF	LF	EF	MF	LF	EF	MF	LF	EF	MF	LF
Cane yield (t/ha)	44.5 (15.3)	43.6 (16.4)	39.9 (4.4)	20.1 (3.7)	18.5 (4.5)	17.3 (4.9)	20.9 (13.8)	19.0 (10.4)	16.2 (7.3)	11.1 (.5)	10.6 (7.9)	5.9 (3.7)
Brix	16.6 (2.5)	16.8 (2.7)	17.1 (2.7)	19.8 (2.2)	20.2 (1.6)	20.8 (1.5)	17.8 (1.2)	17.9 (1.0)	18.1 (0.8)	15.9 (2.1)	15.5 (2.1)	16.6 (2.2)
Stalks/ stool	10.8 (2.4)	10.6 (1.9)	9.9 (2.0)	14.9 (2.6)	13.2 (2.9)	12.5 (2.0)	10.7 (1.8)	9.8 (2.1)	9.9 (2.2)	12.1 (3.6)	8.2 (5.1)	7.9 (4.3)
Millable canes	113.9 (12.0)	113.5 (18.7)	100.8 (17.1)	188.7 (41.4)	157.2 (44.3)	146.4) (22.5)	71.6 (35.9)	63.3 (26.8)	65.0 (27.3)	53.8 (28.1)	34.1 (35.4)	17.5 (13.2)
Stalk Length (m)	2.0 (0.4)	1.9 (0.3)	20.0 (0.3)	1.2 (0.3)	1.3 (0.4)	1.4 (0.2)	1.3 (0.4)	1.4 (0.3)	1.3 (0.2)	1.0 (0.4)	0.8 (0.4)	0.9 (0.4)
Stalk diameter(cm)	3.1 (0.3)	3.0 (0.3)	3.1 (0.3)	2.1 (0.4)	2.2 (0.4)	2.2 (0.3)	2.3 (0.2)	2.3 (0.2)	2.2 (0.2)	2.1 (0.3)	2.1 (0.3)	1.9 (0.2)
No of internodes	19.5 (3.3)	19.6 (4.2)	17.3 (3.2)	13.5 (3.4)	13.3 (3.6)	13.9 (3.0)	11.8 (2.2)	12.8 (3.0)	13.5 (3.0)	13.8 (2.8)	13.0 (2.9)	13.1 (2.9)
Length of internode	12.4 (2.3)	11.3 (1.5)	11.8 (2.4)	11.2 (1.9)	10.5 (1.2)	10.7 (1.8)	11.7 (1.8)	12.4 (1.5)	12.1 (1.3)	11.5 (2.0)	11.9 (2.3)	13.1 (2.6)

Figures in parnethesis is standard errors (S. E.) of the means. EF = Early flowering, MF = Mid flowering , LF = late flowering.

Table 5: Mean days to flowering stages with corresponding brix values

Flowering stage	1992+ Days	1993 Days	Brix	1994 Days	Brix	1995 Days	Brix
Initiation	250±8.29	255.6±0.32	19.1±0.04	258.4±0.21	18.6±0.04	264.3±0.24	17.78±0.04
Flag	261±7.72	273.5±0.29	19.0±0.04	267.6±0.18	18.6±0.04	272.8±0.16	17.39±0.05
Tipping	272±7.05	283.8±0.25	18.9±0.03	276.3±0.20	18.1±0.04	279.1±0.17	16.77±0.05
1st Arrow emergence	280±8.533	294.4±0.24	18.9±0.04	284.7±0.21	17.7±0.05	293.2±0.18	16.46±0.06
50% arrowing	295±3.75	307.4±0.34	18.7±0.04	292.7±0.26	17.5±0.04	297.0±0.04	15.73±0.06

+ Source (Olukoya, 1992)

Table 6. Trend in productivity of selected sugarcane accessions in relation to flowering habit.

Clone	period of Flowering	planted cane		First Ratton		Second Ratoon		Third Ratoon	
		cane yield (t/ha)	Brix (t/ha)	cane yield	Brix (t/ha)	cane yield	Brix	cane yield	Brix
				Shy Flowering					
LSI - 033	Early	81.82	13.5	21.04	19.5	10.72	19.0	11.74	18.0
DB 20/58	Early	53.62	18.5	20.04	22.0	13.40	19.0	21.78	13.5
Co 404	Mid	31.50	14.5	27.58	18.5	20.35	18.0	12.73	13.0
Co 1001	Mid	70.91	12.5	20.87	19.0	9.38	18.0	10.05	14.5
LSI - 085	Late	40.91	18.0	25.46	20.0	14.74	18.0	3.55	12.5
				Profuse Flowering					
Co 691	Early	42.73	14.5	36.18	16.5	23.22	20.5	11.14	12.0
MEX 52/29	Early	57.88	17.0	48.22	18.5	27.73	16.5	12.73	16.5
LSI - 098	Mid	57.88	18.5	14.74	18.5	12.50	17.0	8.43	14.0
B 69620	Mid	63.03	16.0	20.04	18.0	12.68	18.0	26.80	15.5
LSI - 057	Late	50.60	18.0	38.86	18.0	26.70	18.0	14.41	13.0
B 6004	Late	40.00	14.0	20.11	21.5	29.73	18.0	8.38	14.5
LSDα 0.05		17.97	4.4	17.65	2.2	9.01	3.1	14.54	4.5

Table 7. Mean Squares for the components of genotypic effects for cane yield

Source	Df	Cane Yield ms
Harvest stag (HS)	3	18601.33**
Rep/ HS	4	56.98
Genotyupes (G)	47	295.29**
Non Flowering	10	0.51
Early Flowering	15	0.023
Mid Flowering	16	376.13**
Late Flowering	3	1975.61**
Residual	3	642.77**
HS X G	141	144.48**
pooled Error	188	56.74

**** significant at 0.01 level of probability .**

** significant at 0.01 level of probability.

broken down to its different components (Table 7), much of the observed variability were due to the F clones with each of the sub-groups contributing 0.03 (EF), 43.4 (MF) and 42.7 (LF) percent respectively. Therefore, productive genotypes could be evolved by making use of these clones as parents in hybridization programme. The fertility of these F clones from which they could be classified as male or female has been determined (Olaoye, 1996a; Olaoye unpublished results), and study (Olaoye, 1996b) have also shown that under natural conditions, faster progress in varietal development could be achieved by concentrating on the MF x MF or EF x MF crosses. In other words, the genes for high cane yield in these two groups could be utilized in our breeding programme in the development of high yielding sugarcane varieties.

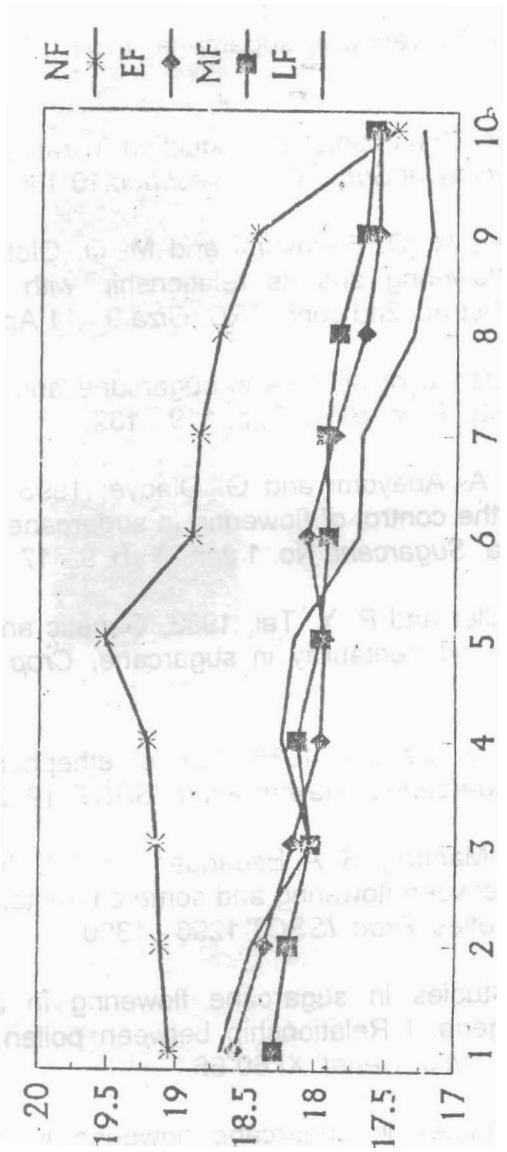

Fig.1. Trend in sucrose content in nonflowering (NF) and flowering (F) sugarcane accessions.

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