Study the Physiological and Biochemical Changes in Popular Flowering Sugarcane (*Saccharum Officinarum*) Varitires

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***Abstract*: Study was undertaken with four flowering sugarcane varieties with a view to investigate the effect on physiological and biochemical changes. Observations have been made from December to February. The total biomass production, single cane weight, length of the cane, girth of the cane, sucrose percent and purity of juice has been decreased. There was an increase in brix percent and fiber content. There is no significant variation in pith content and slight variation in number of internodes. Thus, flowering in sugarcane has no adverse effect till 3rd month after flowering.**

***Keywords*: Sugarcane, Flowering, Effect, Qualities**

INTRODUCTION

Sugarcane is a perennial grass belonging to the family Poaceae. It is an important cash crop grown predominantly in tropical and subtropical climates in India. It is cultivated in more than 4 million hectares of land with an annual cane production of around 270 million tones. India holds the distinction as one of the world's largest producers of sugar. Among the states, Tamil Nadu holds the first place in sugarcane productivity with an average yield of 108 tones/hectares. Sugarcane yield is affected by a number of biotic and abiotic stress factors. Flowering is one of the factors known to affect the productivity of cane and sugar, particularly in southern states of the country. Therefore, from the production viewpoint, heavy flowering is an undesirable trait since it results in reduced cane and sugar yield. Flowering in sugarcane is a genetically determined trait and influenced by a number of factors such as photoperiod, temperature, moisture and nutrition (Moore and Nuss, 1987). Flowering in plants in general is a natural process which marks the culmination of vegetative growth. Flowering in sugarcane is a complex physiological process consisting of multiple stages of development, each stage having specific environmental and physiological requirements. Flowering of sugarcane is very common and profuse in peninsular India during October and November.

The effect on induction of flowering has been examined in a variety of plant species (Zeevart, 1983). Although the flowering of sugarcane is essential for breeding and development of new varieties, uncontrolled flowering in commercial fields poses a serious problems for sugarcane farmers with a considerable loss of sugar as well as cane yield especially in the early flowering varieties. Besides, the harvesting time in India is generally described on the basis of crop age, i.e. 12 to 14 months. The losses due to flowering are reported to be more consistent at low latitudes (Moore and Nuss, 1987). A study was undertaken with four flowering sugarcane varieties with a view to investigate the effect of flowering on fresh cane weight, quality of juice, fiber content , pithiness, for a period of three months after flowering.

MATERIALS AND METHODS

A field experiment was conducted with popular commercial hybrids of sugarcane (*Saccharum officinarum* L) at the main farm of Sugarcane Breeding Institute during the crop season using four early-season flowering varieties BO 91, Co H 15, Co S 8436 and LG 99112.

In this study, the following observations were recorded in the flowered and non-flowered stalks during December, January and February.

Biometric Observations

Dry Matter Production

Samples for dry matter production were made at 1, 2 and 3 months after flowering coinciding with the first week of December, January and February respectively. Two mature stalks were selected at random in each replication. After separating into leaf, stem and shoot the fresh weight of individual parts were recorded. The fresh material was cut into pieces and then dried to a constant weight in a hot air oven at a temperature of 85^{0}C. The dry weights of individual parts were recorded. From this, the total dry weight was computed for each sample.

Single Cane Weight

Four mature canes were selected at random in each variety and stripped free of leaves and sheath till the top. The fresh weight of canes was recorded and from the single cane weight was calculated and expressed in kilograms.

Girth of Cane

Girth of four flowered and non-flowered stalk canes was measured using measuring tape and expressed as average in cm.

Number of Internodes per Stalk

The number of internodes per cane was counted of four randomly selected flowered and non-flowered canes and expressed as average for all the varieties as internodes number.

Cane Length

Length of the randomly selected canes was measured in centimeters from soil surface to topmost node using measuring tape and expressed as average of all four flowered and non-flowered stalks.

Juice Analysis

Samples for juice analysis were made at 1, 2 and 3 months after flowering during the first week of December, January and February respectively. On each sampling occasion, five matured stalks were selected at random in each group in each replication. Each stalk was cut into equal parts and the stalk each replication was crushed individually. The crude juice was filtered through a multifold muslin cloth to remove all the extraneous materials. The filtered juice was taken for the estimation of brix, sucrose, purity as per Meade and Chen, (1977).

Brix

Brix (total solids) was determined by using brix hydrometer spindle. The temperature of the juice was noted and the temperature-corrected reading was expressed as brix percentage.

Sucrose

About 100 ml of juice was clarified using lead acetate and mixed well for decolorisation. The clear transparent filtrate was polarized in a Polariscope to obtain the POL values. The sucrose percent of the juice was obtained from the POL values.

Purity

From the brix and POL values obtained the purity of the juice was calculated using the following formula and expressed in percent.

$$\text{Purity} = (\text{Sucrose \%} / \text{Brix \%}) \times 100$$

Determination of Fiber Percent Cane

Fiber percent cane was estimated by `Rapipol extraction method'. A sample of 250g of chopped cane bits were disintegrated in two litres of water using a Rapipol extractor for 4-5 minutes. After decantation, the contents were washed twice with water and filtered. The residue was transferred to a weighed cloth bag and then dried at 110^0C for 5-6 hrs in an oven until a constant dry weight was obtained. The fiber percent was calculated as the percentage of insoluble residue to the fresh cane weight.

$$\text{Fiber \% cane} = (\text{fiber dry weight} / \text{fresh weight of cane}) \times 100$$

Determination of Pith Content

Using a mesh, the dried fiber material was sieved and pure pith was separated and its weight was recorded. The pith percent was calculated using the following formula expressed as percent.

$$\text{Pith \%} = (\text{pure pith weight/fresh sample weight}) \times 100$$

Statistical Analysis

All the data recorded were statistically analyzed through PENTIUM II computer using the standard software as per the standard procedures of Panse and Sukhatme, 1967. The mean values were compared using critical difference values at 5% level.

RESULTS AND DISCUSSION

Data were recorded in the flowered and non-flowered stalks of four commercial varieties of sugarcane for a period of three months after flowering.

Dry Matter Production

Leaf

The dry matter of leaf decreased from 71.20g in December to 56.99g in February (Table 1). The non-flowered stalks had higher leaf dry matter content than the flowered stalks at all the stages. Naresh Kumar (2000) also reported that the flowering varieties showed lesser dry matter than the non-flowering varieties. Nuss (1989) observed no differences in % dry matter between flowered, naturally vegetative and artificially vegetative canes in any of the varieties studied up to 4 months after flowering.

Stem

The dry matter of stem showed a decreasing trend from 341.44g in December to 269.05g in February (Table 2). The non-flowered stalks had lesser stem dry matter as compared to the flowered stalks at all the stages. The variety LG 99112 recorded the lowest stem dry matter 144.58g in February. The differences among the stalks and stages were statistically significant. The differences among the varieties were not significant. The variety Co H 15 showed the highest stem dry matter 508.89g in December. The stem dry matter had almost a similar pattern as that of total dry matter (Naresh Kumar, 2000). There is an increase in dry matter of stem at induction and different stages of flower development reported by Gururaja Rao *et al*. (1997).

Single Cane Weight

Data on single cane weight were recorded at three stages i.e., December, January and February and given in Table 3. The single cane weight decreased from 0.58 kg in December to 0.49kg in February in the flowered stalks, while it decreased from 0.57kg to 0,54kg in the non-flowered stalks. The differences among the stages and the flowered/non-flowered stalks were statistically not significant. A higher reduction in single cane weight was observed in all the varieties in December and January. Naresh Kumar (2000) reported a similar trend at third month after flowering.

Cane Length

Data on average cane length was recorded at monthly intervals starting from December to February and presented in Table 4. The cane length increased from 160.36cm in December to 161.90cm in February. The non-flowered stalks recorded lesser cane length compared to flowered stalks. The increase in cane length was not much in February over that of December. At all the stages, the interaction between flowered, non-flowered stalks and varieties was statistically not significant. The difference among

the stalks and varieties was also not significant statistically. Jean (2008) reported the cane length of non-flowered stalks was more than flowered stalks. However the increase in cane length was found to be statistically significant.

Number of Internodes per Stalk

Data on the number of internodes per cane stalk recorded during December to February are given in Table 5. The number of internodes per stalk in general did not change much. The flowered stalks recorded lesser number of internodes per stalk as compared to non-flowered stalks. The differences among the flowered and non-flowered stalks and the varieties were statistically significant. The interaction between the stages and variety however, were not significant . Nuss and Maharaj (1992) also reported similar results in flowering variety NCO 376 in South Africa.

Girth of Cane

Data on the girth of stalk at one, two and three months after flowering are given in Table 6. The flowered stalks had more girth than non-flowered stalks at all the stages. The variety Co S 8436 has recorded the highest girth of 2.21cm. The differences among the flowered/non-flowered stalks and the stages were not significant, while the interaction between the flowered /non-flowered stalks, stages, and varieties were statistically significant. Jean (2008) also reported that girth of cane stalk was not influenced by flowering at any of the stages. This could be probably due to the absence of expansive growth of internodes.

Juice Analysis

The juice quality parameters were recorded at monthly intervals for three months after flowering

Brix% Juice

Brix per cent juice increased to 18.32% in January from 17.75% in December and 18.70% in February (Table 7) in both flowered and non-flowered stalks. At all the three stages, the flowered stalks had significantly higher brix % juice than the non-flowered stalks. The variety Co S 8436 had the highest brix% in February. The differences among the varieties and flowered/non-flowered stalks were statistically significant, while none of the interactions was significant. The brix% juice which represents the total solids present, shower an increasing trend from December to February (Jean 2008). Nuss (1989) also reported an increase in brix value in the flowered and non-flowered stalks between May and October i.e., 5 to 6 months after flowering, whereas Rao (1977) observed no appreciable quality difference between the flowered and non-flowered canes.

Sucrose% juice

The sucrose% juice increased to 15.73% in January from 15.62% in December and then decreased to 15.57% in February (Table 8). As in brix per cent juice, the flowered and non-flowered stalks, the trend was similar at all the three stages. The sucrose percent was slightly at 3rd month after flowering variety BO 91 recorded the maximum sucrose per cent juice while variety LG 99112 recorded the minimum sucrose per cent juice. The varieties differed significantly at all the three stages. Similarly, the interaction stage× variety was statistically significant. In the present study, the flowering varieties had recorded higher sucrose content till the third month after the flower emergence. A number of workers had reported reduced yields of sugar as a result of flowering (Naresh Kumar, 2000).

Purity% juice

The purity % showed a decreasing trend from 87.39% in December to 84.23% in February (Table 9). In February, the non-flowered stalks recorded higher purity of juice as compared to flowered stalks. The flowered stalks had a significantly higher purity coefficient at two months after flowering. Variety BO 91 showed a higher juice purity of 94.06% and thr least purity per cent juice 79.31% was noticed in the variety LG 99112. The differences among the varieties, stages and flowered/non-flowered stalks and the interaction were not significant. The purity of juice also showed a tendency of increase until January and then decreased in February as observed in an earlier finding by Gururaja Rao *et al.* (1997).

Fiber Per Cent Cane

The fiber per cent cane decreased from 14.95% in December to 13.72% in February (Table 10). The non-flowered stalks had lesser fiber content in December and February. The varietal differences were statistically significant. Variety Co H 15 had higher fiber content, while Co S 8436 had the least fiber content. The differences among the stages, varieties were statistically significant, while the interaction were not significant. Miah and Sarkar (1981) reported that the flowering stalks had higher fiber% cane upto 60 days after flowering.

Pith Content

Data on the percentage of pith in total fiber at 1,3 months after flowering are presented in Table 11. The variety Co S 8436 had 32.30% of fiber as pith in December and increased to 34.84% of fiber in February. Variety Co H 15 had recorded lower pith per cent 30.82% of fiber than the rest in December. The differences between the flowered and non-flowered stalks were statistically significant. Rao (1977) noted extensive pithiness of flowered canes, the pithiness of the flowered varieties ranged only from 26 to 40 % of total fiber by February. The absence of pith development can be due to the favourable climatic conditions that existed in February.

CONCLUSION

Observations have been made from December to February and the conclusions made are the total biomass production, single cane weight, length of the cane, girth of the cane, sucrose percent and purity of juice has been decreased. There was an increase in brix percent and fiber content. There is no significant variation in pith content and slight variation in number of internodes. Thus, flowering in sugarcane has no adverse effect till 3rd month after flowering.

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Table 1. Leaf dry weight (g) at different stages after flowering

Variety	Dec. 2010			Jan. 2011			Feb. 2011		
	F	NF	Mean	F	NF	Mean	F	NF	Mean
B0 91	81.76	87.67	84.71	49.16	130.57	89.87	14.29	97.97	56.13
COH15	20.33	60.69	40.51	80.95	78.67	79.82	34.36	90.79	62.58
COS 8436	81.15	73.82	77.49	58.98	81.72	70.35	20.28	75.57	47.93
LG 99112	57.97	106.21	82.09	64.96	142.10	103.53	26.24	96.39	61.31
Mean	**60.30**	**82.10**	**71.20**	**63.51**	**108.27**	**85.89**	**23.79**	**90.18**	**56.99**

	SE	CD
Flowered vs Non-flowered stalks	4.743	9.81
Stage	5.809	12.01
Variety	6.707	NS
Stalks×Stage	8.214	NS
Stalks×Variety	9.485	NS
Stage×Variety	11.617	NS
Stalks×Stage×Variety	16.429	NS

Table 2. Stem dry weight (g) at different stages after flowering

Variety	Dec. 2010			Jan. 2011			Feb. 2011		
	F	NF	Mean	F	NF	Mean	F	NF	Mean
B0 91	390.27	254.69	322.48	314.21	169.70	241.96	322.69	195.89	259.29
COH15	633.16	384.62	508.89	584.73	207.32	396.02	503.92	197.51	350.72
COS 8436	434.09	256.77	345.43	431.80	151.54	291.67	386.95	256.27	321.61
LG 99112	211.83	166.05	188.94	225.67	225.45	225.45	112.12	177.04	144.58
Mean	**417.34**	**265.53**	**341.44**	**389.10**	**188.45**	**288.78**	**331.42**	**206.68**	**269.05**

	SE	CD
Flowered vs Non-flowered stalks	12.50	25.86
Stage	15.31	31.67
Variety	17.68	NS
Stalks×Stage	21.66	NS
Stalks×Variety	25.01	NS
Stage×Variety	30.63	63.37
Stalks×Stage×Variety	43.32	NS

Table 3. Single cane weight (kg) at three months after flowering

Variety	Dec. 2010			Jan. 2011			Feb. 2011		
	F	NF	Mean	F	NF	Mean	F	NF	Mean
B0 91	0.58	0.49	0.49	0.58	0.61	0.60	0.48	0.55	0.51
COH15	0.79	0.72	0.75	0.79	0.75	0.77	0.58	0.62	0.60
COS 8436	0.61	0.64	0.63	0.73	0.76	0.75	0.56	0.61	0.59
LG 99112	0.43	0.43	0.43	0.37	0.34	0.36	0.36	0.38	0.37
Mean	**0.58**	**0.57**	**0.57**	**0.62**	**0.61**	**0.62**	**0.49**	**0.54**	**0.52**

	SE	CD
Flowered vs Non-flowered stalks	0.026	NS
Stage	0.032	NS
Variety	0.037	0.07
Stalks×Stage	0.046	NS
Stalks×Variety	0.053	NS
Stage×Variety	0.065	NS
Stalks×Stage×Variety	0.092	NS

Table 4. Length of cane (cm) at monthly intervals after flowering

Variety	Dec. 2010			Jan. 2011			Feb. 2011		
	F	NF	Mean	F	NF	Mean	F	NF	Mean
B0 91	185.30	115.10	150.20	222.10	162.00	192.05	152.90	164.90	158.90
COH15	212.90	218.20	215.55	237.90	223.10	230.50	212.50	230.60	221.55
COS 8436	150.10	132.90	141.50	165.40	151.10	158.25	122.40	151.30	136.85
LG 99112	167.60	101.10	134.35	132.80	145.60	139.20	116.30	144.30	130.30
Mean	**178.90**	**141.82**	**160.36**	**189.55**	**170.45**	**180.00**	**151.02**	**172.77**	**161.90**

	SE	CD
Flowered vs Non-flowered stalks	16.72	NS
Stage	20.48	NS
Variety	23.65	NS
Stalks×Stage	28.97	NS
Stalks×Variety	33.45	NS
Stage×Variety	40.97	NS
Stalks×Stage×Variety	57.94	NS

Table 5. Number of internodes / stalk at monthly intervals after flowering

Variety	Dec. 2010			Jan. 2011			Feb. 2011		
	F	NF	Mean	F	NF	Mean	F	NF	Mean
B0 91	19.90	13.20	16.55	18.50	14.30	16.40	15.10	15.70	15.40
COH15	19.50	18.90	19.20	19.70	19.70	19.70	18.60	20.90	19.75
COS 8436	18.50	15.70	17.10	21.90	19.10	20.50	16.30	20.80	18.55
LG 99112	17.90	14.30	16.10	17.20	13.50	15.35	15.50	15.70	15.60
Mean	**18.95**	**15.53**	**17.24**	**19.33**	**16.65**	**17.99**	**16.38**	**18.28**	**17.33**

	SE	CD
Flowered vs Non-flowered stalks	0.28	0.57
Stage	0.34	NS
Variety	0.40	0.82
Stalks×Stage	0.49	1.01
Stalks×variety	0.57	1.17
Stage×variety	0.69	NS
Stalks×stage×variety	0.98	NS

Table 6. Girth of cane (cm) at three months after flowering

Variety	Dec. 2010			Jan. 2011			Feb. 2011		
	F	NF	Mean	F	NF	Mean	F	NF	Mean
B0 91	2.03	1.83	1.93	2.18	2.03	2.11	1.73	2.15	1.94
COH15	2.14	1.81	1.97	2.61	1.67	2.14	1.79	1.80	1.79
COS 8436	2.16	2.26	2.21	2.23	2.11	2.17	2.24	2.24	2.24
LG 99112	1.67	2.10	1.88	1.80	2.01	1.90	1.75	2.13	1.94
Mean	**2.00**	**2.00**	**2.00**	**2.20**	**1.96**	**2.08**	**1.88**	**2.08**	**1.94**

	SE	CD
Flowered vs Non-flowered stalks	0.04	NS
Stage	0.05	NS
Variety	0.06	0.12
Stalks×Stage	0.07	0.14
Stalks×Variety	0.08	0.16
Stage×Variety	0.10	NS
Stalks×Stage×Variety	0.14	NS

Table 7. Brix per cent juice at one two and three months after flowering

Variety	Dec. 2010			Jan. 2011			Feb. 2011		
	F	NF	Mean	F	NF	Mean	F	NF	Mean
B0 91	20.55	16.10	18.32	20.33	18.78	19.51	19.57	18.55	19.06
COH15	18.52	20.32	19.42	18.81	17.17	17.99	18.83	17.48	18.15
COS 8436	18.44	15.85	17.15	18.90	18.57	18.74	20.51	19.13	19.82
LG 99112	17.18	15.09	16.14	16.76	17.31	17.03	18.07	17.45	17.76
Mean	**18.67**	**16.84**	**17.75**	**18.68**	**17.96**	**18.32**	**19.24**	**18.15**	**18.70**

	SE	CD
Flowered vs Non-flowered stalks	0.27	0.55
Stage	0.33	NS
Variety	0.39	0.80
Stalks×Stage	0.47	NS
Stalks×Variety	0.55	NS
Stage×Variety	0.67	NS
Stalks×Stage×Variety	0.95	NS

Table 8. Sucrose per cent juice at one two and three months after flowering

Variety	Dec. 2010			Jan. 2011			Feb. 2011		
	F	NF	Mean	F	NF	Mean	F	NF	Mean
B0 91	19.24	13.66	16.45	18.03	16.26	17.14	17.66	18.06	17.86
COH15	16.71	18.71	17.71	16.02	14.24	15.13	13.86	14.13	14.00
COS 8436	16.80	13.27	15.03	16.19	15.97	16.08	16.40	16.78	16.59
LG 99112	14.57	12.02	13.30	14.66	14.47	14.56	13.83	13.86	13.85
Mean	**16.83**	**14.42**	**15.62**	**16.22**	**15.23**	**15.73**	**15.44**	**15.71**	**15.57**

	SE	CD
Flowered vs Non-flowered stalks	0.27	0.55
Stage	0.33	NS
Variety	0.38	0.78
Stalks×Stage	0.47	NS
Stalks×Variety	0.54	NS
Stage×Variety	0.67	1.38
Stalks×Stage×Variety	0.95	NS

Table 9. Purity per cent juice at one two and three months after flowering

Variety	Dec. 2010			Jan. 2011			Feb. 2011		
	F	NF	Mean	F	NF	Mean	F	NF	Mean
B0 91	93.65	84.97	89.31	89.11	86.52	87.82	90.39	97.72	94.06
COH15	88.81	92.13	90.47	85.15	82.79	83.97	73.60	85.58	79.59
COS 8436	91.41	83.72	87.57	85.62	85.93	85.78	80.24	87.71	83.98
LG 99112	84.69	79.73	82.21	87.69	83.49	85.59	78.19	80.42	79.31
Mean	**89.64**	**85.14**	**87.39**	**86.89**	**84.68**	**85.79**	**80.60**	**87.86**	**84.23**

	SE	CD
Flowered vs Non-flowered stalks	2.21	NS
Stage	2.71	NS
Variety	3.13	NS
Stalks×Stage	3.83	NS
Stalks×Variety	4.43	NS
Stage×Variety	5.42	NS
Stalks×Stage×Variety	7.67	NS

Table 10. Pith per cent fiber at one and three months after flowering

Variety	Dec 2010			Feb 2011		
	F	NF	Mean	F	NF	MEAN
B0 91	30.28	35.07	32.68	28.92	38.19	33.56
COH15	32.40	29.24	30.82	32.24	30.92	31.58
COS 8436	32.26	39.34	35.80	32.30	37.38	34.84
LG 99112	30.90	31.41	31.15	28.79	33.30	31.05
Mean	**31.46**	**33.76**	**32.61**	**30.56**	**34.95**	**32.76**

	SE	CD
Flowered vs Non-flowered stalks	1.05	2.23
Stage	1.05	NS
Variety	1.48	NS
Stalks×Stage	1.48	NS
Stalks×Variety	2.10	NS
Stage×Variety	2.10	NS
Stalks×Stage×Variety	2.97	NS

Table 11. Fiber per cent cane at one and three months after flowering

Variety	Dec. 2010			Feb. 2011		
	F	NF	Mean	F	NF	Mean
B0 91	16.83	14.57	15.70	15.46	13.20	14.33
COH15	16.97	16.42	16.70	15.60	15.24	15.42
COS 8436	13.48	11.18	12.33	12.40	10.13	11.26
LG 99112	15.86	14.28	15.07	14.54	13.22	13.88
Mean	**15.79**	**14.11**	**14.95**	**14.50**	**12.95**	**13.72**

	SE	CD
Flowered vs Non-flowered stalks	0.14	0.29
Stage	0.14	0.29
Variety	0.20	0.42
Stalks×Stage	0.20	NS
Stalks×Variety	0.29	0.61
Stage×Variety	0.29	NS
Stalks×Stage×Variety	0.41	NS