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STUDIES ON GENETIC VARIABILITY AND COMBINING ABILITY IN SUGARCANE

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ABSTRACT

High genotypic coefficient of variation, heritability and genetic advance were obtained for number of canes, stalk height and brix per cent (11th and 13th month), while low heritability and high genetic advance were obtained for stalk height and the moderate for the rest of the characters. The combining ability analysis indicated that gca effects were positively significant for number of canes, stalk height, girth, weight and brix. Both the additive and non-additive type of gene actions were found important for yield attributes and only additive type of gene action was important for brix per cent.

Key words: Genetic variability, combining ability, sugarcane.

The genetic determinants and combining ability are becoming increasingly important in choosing the proper parents for hybridization [1, 2]. Therefore, an attempt has been made in this direction through top cross analysis.

MATERIALS AND METHODS

Ten crosses were made during 1984, using ten lines: S 3176/76, S 8020/77, S 3518/77, S 1577/77, S 3485/77, S 3366/77, S 229/78, CoS 7903, CoS 8022 and CoS 8122, and S 9/76 was as tester in top cross design.

The F_1 seedlings of these crosses were raised in nursery bed for 12 months after which 20 random seedlings from each cross were transplanted along with their parents in randomised block design with two replications. Data on number of millable canes, number and length of internodes, leaves/stalk, stalk height (cm), stalk girth (cm), stalk weight and brix per cent at 11th and 13th months were recorded. Genotypic and phenotypic coefficient of variation [1], heritability and genetic advance [2, 3] were estimated. The cross and parental means were utilized for combining ability analysis as suggested by Kempthorne et al. [4].

RESULTS AND DISCUSSION

The analysis of variance (Table 1) showed highly significant differences for treatments, parents (except for stalk girth and number of leaves), and crosses (except for canes/clump,

Table 1. Analysis of variance (mean squares) in sugarcane

Source	d.f.	Millable canes/ clump	No. of inter- nodes	Inter- node length	No. of green leaves	Stalk girth	Stalk height	Cane weight	Brix	
									11th month	13th month
Replications	1	17.2	0.2	4.3	0.29	0.14	34.6	422.0	0.51	1.05
Treatments	20	95.2**	19.6**	5.9**	1.74**	0.18*	1497.8*	17926.8*	10.54**	7.24**
Parents	10	141.1**	34.3**	5.4**	0.66	0.30	2341.4**	19826.9**	5.84**	4.17**
Crosses	9	21.8	14.2**	4.2**	1.29**	0.06	654.3	17182.5**	1.15	3.30*
Parents vs. crosses	1	300 9*	83.1**	25.6**	16.63**	0.03	753.9	35624.4**	142**	74.15**
Error	20	11.4	5.0	1.5	0.56	0.64	578.4	2711.0	1.37	1.18

*,**Significant at 5% and 1% levels, respectively.

stalk girth and height) for all the characters, indicating sufficient genetic variability and diversity among the parents. Similar trend was obtained for parents vs crosses for all the characters except stalk girth and height.

The higher genotypic coefficient of variation (GCV) for the number of millable canes, stalk weight and brix indicated that about 90% phenotypic expression of these characters was due to genotypic components, whereas the stalk height and girth registered comparatively lower GCV (Table 2). Number of millable canes, stalk weight and brix had high heritability and high genetic advance, suggesting better scope for the advancement through straight selection [5, 6]. Similar results have been reported by [7, 8]. According to Lerner [8], the estimates of broadsense heritability are reliable if combined with high genetic advance, indicating role of additive gene action which gives better response for selection than those characters having low values. Although Hogarth [2] suggested that broadsense heritability is meaningful in sugarcane since all types of genetic variability are useable between asexual generations. In the present study, stalk height had low heritability (44.4) and high genetic advance (29.7). This may be because of the high phenotypic variation for this character. Thus, high heritability does not necessarily ensure high genetic advance. These results indicated that yield could be improved by giving due weightage to stalk number and stalk weight.

Table 2. Genetic parameters in sugarcane

Components of variation	Millable canes per clump	No. of inter-nodes	Inter-node length	No. of green leaves	Stalk girth	Stalk height	Cane weight	Brix 11th month	Brix 13th month
Coefficient of variance (CV)	21.7	12.7	12.1	11.3	11.9	16.0	11.7	6.6	5.9
Phenotypic coefficient of variation (PCV)	46.2	19.9	19.8	16.2	15.8	21.5	21.4	13.7	11.0
Genotypic coefficient of variation (GCV)	40.9	15.5	15.2	11.6	11.2	14.8	21.0	12.1	9.3
GCV/PCV ratio	0.9	0.8	0.8	0.7	0.7	0.8	0.9	0.9	0.8
Hertability (%)	88.6	59.8	58.8	51.1	50.4	44.4	73.1	76.6	72.0
Genetic advance	13.3	4.3	2.3	1.2	0.3	29.7	152.8	3.9	3.0

Moderate GCV, heritability and genetic advance were recorded for stalk girth, height and number of leaves [9], which indicates that these characters were under greater environmental influence and selection based on these attributes would be ineffective. The ratio, GCV/PCV, heritability and genetic advance indicated that brix per cent was less influenced by environment and was therefore, largely controlled by genotypic components and this character will express consistently in succeeding generations, leading to greater efficiency of a breeding programme.

General combining ability (gca) effects. The lines, CoS 8022 and S 3366/77 exhibited highly significant positive gca effects for all the yield components, except number of leaves, and were poor combiners for brix per cent. On the other hand, the lines CoS 7903 and S 9/76 were found to be significantly poor combiners for cane numbers, stalk girth, height and stalk weight but were significantly good combiners for brix per cent, while, the line S 1577/77 consistently exhibited significantly positive gca effects for brix per cent and negatively for yield attributes except millable cane and length of internode (Table 3). Thus, stalk weight, length and stalk girth had antagonistic relationship with brix per cent. These results lead to the conclusion that the parents would be good general combiners for stalk weight if they possess high gca for stalk length and/or stalk girth. These results are in agreement with the earlier findings of [10, 11]. Thus, it was difficult to select a good general combiner for all the characters simultaneously as the combining ability effects were not in the same direction for all the characters because of negative associations and mutual cancellation of each others.

Specific combining ability (sca) effects. The specific cross combinations for different yield components and brix are listed in Table 4. The crosses CoS 8022 x S 9/76 and S 2820/77 x S

Table 3. General combining ability effects in sugarcane

Parent variety	Millable canes/clump	No. of inter-nodes	Inter-node length	No. of green leaves	Stalk girth	Stalk height	Cane weight	Brix 11th month	Brix 13th month
S 2820/77	2.63**	0.03	1.90**	0.04	- 0.19**	9.86	25.60	0 90**	0.07
CoS 8122	- 0.36**	- 7.18**	- 1.85**	2.64**	- 0.20**	28.86**	43.1*	1.25**	- 1.6**
S 3518/77	1.64*	- 2.82**	3.30**	0.34	- 0.25**	33.86**	44.6*	- 1.85**	- 1.35**
S 1577/77	0.64	- 0.42	0.80**	- 0.09	- 0.26**	- 7.64	- 33.6	2.80**	1.10**
S 3485/77	1.14	- 0.42	0.00	- 0.09	- 0.20	- 1.14**	18.20	0.75**	0.35
CoS 7903	- 7.36**	- 1.20**	- 1.75**	0.09	- 0.10	- 34.14**	- 149.19	0.90**	0.70**
S-9/76	- 7.86**	- 2.12**	- 1.85**	0.14	0.85**	- 30.14**	- 124.10	2.80**	2.65**
CoS 8022	7.64**	8.12**	0.15	- 0.09	0.21**	50.86**	102.90**	- 1.40**	- 1.40**
S 229/78	14.14**	- 0.13	- 1.15**	- 0.01	- 0.20**	- 31.14**	- 103.10	- 1.35**	- 0.85**
S 3366/77	9.14**	1.07*	0.60	0.89**	0.05	41.86**	115.50**	- 0.95**	- 0.45
S 3176/76	- 11.36**	- 6.38**	- 0.15	- 0.15	0.56**	- 41.14**	43.50*	- 1.30**	- 0.85**
SE (gca) ±	0.73	0.47	0.26	0.17	0.06	5.13	15.70	0.25	0.23

*,**Significant at 5% and 1% levels, respectively.

9/76 showed positively significant sca effects for stalk weight and height. These results indicate that cane weight is largely dependent on stalk height. Miller [12] also suggested that cane weight is largely dependent on stalk girth and stalk height with predominantly additive type of gene action.

Considering the per se performance and the gca effects of the parents, the high x high cross combination S 2820/77 x S 9/76 exhibited significant sca effects for brix per cent, which indicates predominance of additive x additive gene action. The high x low cross combinations CoS 8022 x S 9/76 and S 2820/78 x S 9/76 exhibited significant positive for sca effects major yield components like number and length of internodes, stalk height and cane weight, and the low x low cross S 3366/77 x S 9/76 showed significant negative sca effects for most of the metric traits, including brix per cent. The crosses with high sca effects involving at least one good general combiner parent yield desirable transgressive segregates. Langham [13] also suggested that high x low cross combinations produce better transgressive segregates in later generations, while Rahman and Nageswara Rao [14] concluded that brix is under nonadditive type of gene action and low x low and high x low general combiners give heterotic effects. It was interesting to note that the high x low cross S 3366/77 x S 9/76 exhibited significant negative sca effects for most of the characters, may be due to epistatic

Table 4. Specific combining ability effects in sugarcane

Cross	Millable canes per clump	No. of internodes	Internode length	No. of green leaves	Stalk girth	Stalk height	Cane weight	Brix 11th month	Brix 13th month
S 3518/77 x S 9/76	0.70	- 1.59**	- 0.7*	6.14**	- 0.16**	- 4.2	118.1**	- 0.67	- 0.90**
S 3176/76 x S 9/76	- 2.60	1.24**	- 0.03	- 0.46*	- 0.16	- 5.7	- 50.6**	- 0.88**	- 0.70**
S 3485/70 x S 9/76	- 2.50	0.64	- 0.65*	- 0.71**	- 0.16	- 10.2	- 104.6**	- 0.97**	- 0.70**
S 3366/77 x S 9/76	- 4.30	- 4.94**	- 1.20**	- 1.61**	0.15	- 25.2**	- 11.1	1.33**	1.70**
CoS 7903 x S 9/76	- 2.50	0.71	- 1.40**	- 0.76**	0.25**	- 6.2	9.0	- 0.62*	0.05
S 2820/77 x S 9/76	- 0.45	2.01**	0.50	0.64**	0.20	15.4**	99.0**	0.48	1.40**
S 1577/77 x S 9/76	- 2.00	0.16	1.00*	0.40*	0.15	- 22.7**	107.6**	0.18	- 0.43
CoS 8122 x S 9/76	4.5	2.26**	0.01	0.59**	- 0.01	- 14.4*	114.5**	- 0.72	- 0.30
CoS 8022 x S 9/76	6.1*	1.16*	3.60**	1.39**	- 0.11	31.9**	109.5**	0.28	- 0.01
S 229/78 x S 9/76	1.85	1.61**	- 0.70	0.49**	- 0.16	12.4*	59.0**	- 0.17	0.01
SE (sca) ±	2.39	0.50	0.26	0.16	0.18	5.5	11.6	0.26	0.24

*,**Significant at 5% and 1% levels, respectively.

type of gene action or mutual cancellation of the genes. It must be mentioned that our results do not support the view that the parents with good gca effects always exhibit good sca effects when crossed together.

On the basis of genetic determinants and combining ability analysis, it may be concluded that number of millable canes, stalk weight and brix were under the influence of additive gene action. The lines CoS 8022, S 3366/77 and S 3518/77 were good general combiners for yield components, whereas the parents S 9/76, S 1577/76 and CoS 7903 were good general combiners for brix per cent, and line S 2820/77 was a good general combiner for both. High x low crosses CoS 8022 x S 9/76 and S 2820/77 x S 9/76 and the low cross CoS 8122 x S 9/76 showed significant positive sca effects for yield attributes and negative for brix per cent. The cross between S 2820/77 (high gca parent for yield components and brix per cent) and S 9/76 (good for brix per cent) exhibited high sca effects for both brix per cent as well as yield attributes, indicating that both the parents are complementary to each for these traits. On the contrary, the high x low cross S 3366/77 x S 9/76 gave negative sca effects for most of the traits. This may be due mutual cancellation of gene effects. The close relationship between per se performance and combining ability effect is due to predominance of additive and nonadditive gene actions for yield components and additive and additive x additive types of gene action for brix per cent. Under such situation, appropriate method of recurrent selection after biparental mating should be adopted for yield attributes, straight selection may be exercised for brix per cent.

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