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CHARACTER INTERRELATIONSHIPS IN CULTIVAR x SPECIES PROGENIES IN SUGARCANE

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ABSTRACT

Character associations were studied in the progenies of Indian sugarcane cultivars crossed with *S. officinarum* (HO), *S. spontaneum* (HS) and *S. sinense/barberi* (HB). Correlation coefficients between cane yield, its components, and quality characters varied amongst the three mating groups. Path analysis revealed that No. of stalks and sucrose content were important components of sugar yield in HO group, whereas cane diameter and sucrose content were important in HS group. In the HB mating group, sucrose content was the most important character and it had positive association with all the quantitative traits except NMC.

Key words: Correlation coefficients, path analysis, mating groups, *Saccharum* spp.

Increasing the efficiency of interspecific hybridization in sugarcane is a long-cherished goal in nobilization. In sugarcane, correlation and path analysis [1-5] have been helpful in advanced selection programme for improving the crop potential. But lack of information on the relative merits of individual characters in the various mating groups of interspecific hybrids remains a lacuna in increasing their production efficiency. The present investigation aims to estimate correlation and direct and indirect relationships between the various yield and quality attributes and their relative impact on sugar yield in the F_1 hybrids of three mating groups involving *Saccharum* spp. which showed intergroup differences in variability, heritability and genetic advance (Bakshi Ram and G. Hemaprabha, unpublished).

MATERIALS AND METHODS

The experimental material comprised F_1 progenies from crosses involving commercial Indian hybrids and *S. officinarum* (HO), *S. spontaneum* (HS), and *S. barberi/sinense* (HB). Eight clones each of *S. officinarum, S. spontaneum* and *S. barberi/sinense* were used in hybridization

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(Table 1). The progenies at the seedling stage were subjected to selection so as to surpass the threshold limits set up for each group for H. R. Brix 18% for all the groups, number of millable canes (NMC) for HO group, and cane diameter and single cane weight for HB group to reduce the number to a manageable level. Hybridity of the progenies was confirmed by distinct economic potential characteristic of each species. Twenty five progenies in each mating group were taken at random. The progenies along with three checks, viz. Co 62175, Co 6304 and CoC 671, were evaluated in randomized block design with three replications. Each F_1 clone was grown in a single-row plot, 6 m long, spaced 90 cm apart. Twenty three-budded setts were planted in a plot at equal distance. The trial was harvested after 360 days and the data on eleven quantitative characters recorded adopting the standard procedures. The correlation and path coefficient analyses were carried out in three mating groups as per the method described by Dewey and Lu [6]. The significance of phenotypic correlation coefficients was tested as per [7].

RESULTS AND DISCUSSION

The interrelationships among cane yield and its components (Table 2) showed that NMC, cane length, and single cane weight were the characters of great importance for increasing cane yield in the HO mating group, whereas NMC and single cane weight were the most important components of cane yield in the HB group. In particular, none of the quantitative characters was so much important for cane yield except NMC having a low positive relationship in the HS mating group. The association between cane length and cane yield was significant only in HO group (0.51). Amongst the component characters of cane yield, the correlations between NMC and single cane weight and NMC and cane diameter were negative and high in the HS and HB mating groups, but they were negative and nonsignificant in the HO group. Relationship between cane diameter and cane density was negative and highest in the HO mating group, followed by HS group, but was nonsignificant in HB group.

Table 1. List of crosses and number of progenies in three mating groups of sugarcane

HO cross	No. of progenies	HS cross	No. of progenies	HB cross	No. of progenies
Cebu Lt. Purple x MS 68/47	4	CoC 671 x Dacca	4	Anjmia x MS 68/47	3
Fiji 40 x Co 62174	2	Co 62174 x Hazuda	3	Kansar x MS 68/47	3
Co 1307 x Keong	3	Co 62174 x IMP 1532	3	Khakai x Co 1307	3
Koelz 11132 x MS 68/47	2	CoC 671 x SES 14	3	Mangwa x Co 1148	3
Naz x MS 68/47	3	Co 775 x SES 49	3	Pansahi x Co 1307	3
Saipan G x Co 62174	3	CoC 671 x SES 268	3	Pathri x Co 62174	4
28 NG 221 x MS 68/47	4	Co 62174 x SES 515/3	3	Uba Seedling x Co 62174	3
57 NG 203 x MS 68/47	4	CoC 671 x SES 574	3	Uba White x Co 62174	3

Table 2. Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients among yield and quality parameters in three mating groups of sugarcane

Character	Group	NMC	Cane diameter	Cane length	Cane density	Single cane weight	Cane yield	Brix %	Sucrose content	Purity %	CCS %	CCS per plot
NMC	HO	—	–0.26	–0.05	–0.02	–0.26	0.50*	0.17	0.14	0.08	0.14	0.51**
	HS	—	–0.80**	–0.33	0.14	–0.81**	0.40*	–0.42*	–0.49*	–0.54**	–0.51**	–0.01
	HB	—	0.47*	–0.11	–0.10	–0.50*	0.43*	–0.22	–0.25	–0.30	–0.27	0.16
Cane diameter	HO	–0.46	—	0.14	–0.50*	0.61**	0.29	–0.08	–0.06	0.01	–0.06	0.19
	HS	–0.89	—	0.27	–0.41*	0.87**	–0.04	0.37	0.44*	0.46*	0.46*	0.26
	HB	–0.61	—	0.17	–0.37	0.64**	0.22	0.13	0.18	0.27	0.13	0.30
Cane length	HO	–0.14	–0.11	—	–0.01	0.56**	0.51**	–0.13	–0.19	–0.28	–0.21	0.31
	HS	–0.43	0.37	—	–0.24	0.50*	0.28	–0.02	–0.00	0.09	0.01	0.24
	HB	–0.14	0.05	—	–0.01	0.50*	0.37	0.12	0.06	–0.11	0.07	0.33
Cane density	HO	0.06	0.14	0.96	—	0.24	0.24	–0.18	–0.22	–0.29	–0.23	0.06
	HS	0.27	–0.40	–0.24	—	–0.08	0.08	0.22	0.17	0.01	0.12	0.12
	HB	–0.17	–0.06	0.66	—	0.37	0.28	0.13	0.09	–0.05	0.08	0.26
Single cane weight	HO	–0.31	0.72	0.63	0.77	—	0.66**	–0.25	–0.28	–0.31	0.29	0.36
	HS	–0.86	0.94	0.56	–0.20	—	0.09	0.46*	0.49*	0.45*	0.50*	0.39
	HB	–0.61	0.79	0.52	0.55	—	0.54**	0.26	0.25	0.15	0.20	0.58**
Cane yield	HO	0.55	0.15	0.55	0.79	0.59	—	–0.06	–0.11	–0.19	–0.12	0.76**
	HS	0.42	–0.13	0.26	0.09	–0.02	—	0.03	–0.02	–0.10	–0.04	0.76**
	HB	0.49	0.16	0.36	0.39	0.38	—	0.13	0.08	0.08	0.02	0.81**
Brix %	HO	0.27	–0.21	–0.73	–0.29	–0.45	–0.17	—	0.96**	0.67**	0.93**	0.55**
	HS	–0.57	0.54	0.12	0.15	0.57	–0.10	—	0.95**	0.64**	0.91**	0.57**
	HB	–0.35	0.21	0.01	0.39	0.37	0.09	—	0.97**	0.68**	0.89**	0.61**
Sucrose content	HO	0.20	–0.19	–0.75	–0.39	–0.48	–0.24	0.98	—	0.84**	0.99**	0.53**
	HS	–0.62	0.59	0.13	–0.02	0.58	–0.15	0.99	—	0.83**	0.99**	0.59**
	HB	–0.38	0.26	–0.11	0.25	0.32	–0.01	0.98	—	0.84**	0.94**	0.59**
Purity %	HO	0.14	–0.15	–0.69	–0.54	–0.50	–0.31	0.87	0.95	—	0.88**	0.38
	HS	–0.74	0.67	0.23	–0.44	0.59	–0.29	0.89	0.93	—	0.88**	0.48**
	HB	–0.46	0.42	–0.44	–0.24	0.15	–0.28	0.76	0.87	—	0.83**	0.41*
CCS %	HO	0.19	–0.19	–0.76	–0.41	–0.49	–0.26	0.96	0.99	0.98	—	0.52**
	HS	–0.65	0.62	0.11	–0.10	0.58	–0.17	0.99	0.99	0.95	—	0.46*
	HB	–0.42	0.22	–0.11	0.13	0.24	–0.13	0.98	1.01	0.87	—	0.59**
CCS/plot	HO	0.67	–0.00	0.12	0.53	0.27	0.83	0.40	0.33	0.23	0.31	—
	HS	–0.05	0.27	0.29	0.08	0.35	0.76	0.55	0.51	0.39	0.50	—
	HB	0.17	0.34	0.26	0.45	0.54	0.87	0.59	0.51	0.19	0.38	—

*,**Significant at P = 0.05 and P = 0.01, respectively.

The associations between CCS per plot and cane yield and its components varied from low negative to high positive. Correlation coefficients between NMC and CCS per plot in the HO group (0.51) and single cane weight and CCS per plot in the HB group (0.58) were significant. High positive relationship was observed between cane yield and CCS per plot in all the three mating groups. All other associations were nonsignificant.

The interrelationships between component characters of cane yield and quality parameters varied widely among the three mating groups. The associations of NMC with quality characters were negative and significant only in the HS mating group. The inverse relationship between NMC and quality traits in the HS group indicates that the photosynthetic assimilates are mainly utilised for production and growth of stalks rather than storage of sugars in the canes because the HS genotypes produced very high NMC in comparison with other groups. But in HO and HB groups, the photosynthates are accumulated in relatively fewer canes, resulting in higher sucrose content. Further, cane diameter and single cane weight showed moderately positive correlation with quality characters in the HS mating group. This means that cane diameter is an important character for selecting better quality genotypes, particularly among the HS genotypes. Cane density was introduced as an additional intermediate character particularly for understanding its associations with quality characters to improve selection efficiency at seedling stage when juice analysis is difficult. Its relationships with quality characters were negative in the HO mating group, but positive in the HS and HB groups, although none of these associations was significant.

Moderate to high correlations were observed between CCS per plot and quality parameters. The interrelationships among quality characters were also high and positive. These relationships did not vary much amongst the mating groups.

A comparison of genotypic and phenotypic correlation coefficients revealed that the environment played an important role in determining the interrelationships among the cane yield characters in the HO groups and between cane yield and quality attributes in HS and HB mating groups. But the differences between genotypic and phenotypic correlations were not evident among quality characters in the three mating groups. Mariotti [1] also reported that environment did not play an important role in determining the quality characters. The genotypic correlation coefficient between sucrose content and CCS % exceeded unity (1.01); this may be due to error in estimation [8–10] or negative environmental association between traits [11].

The most useful overall measure of the commercial potential of a genotype is the quantity of CCS produced per unit area. It is the intention of every breeder to concentrate initially on the characters for which measurements can be taken directly in the experiment, such as, NMC, cane diameter, cane length, Brix % and sucrose content; and then to consider the derived variables like cane volume, single cane weight, and CCS %, calculated numerically from the primary observations. Keeping this in view, only primary characters (except cane density) were considered. Phenotypic correlation coefficients were considered for path analysis as it gives greater precision than genetic correlations when two correlations (genetic and phenotypic) differ appreciably in magnitude [12].

Comparing the direct effects with correlation coefficients (Table 3), the differences were less for NMC in the HO mating group, for cane length in both HO and HB groups, and for sucrose content in the HB group, suggesting a true relationship between the traits. On the contrary, wide variations were observed between the two values for many character associations. Direct effects were much higher than the correlation coefficients for cane diameter, whreas Brix % itself was not an important component of sugar yield, as indicated by correlation values in all the three mating groups. The high correlation coefficient was mainly due to its higher indirect effects through sucrose content. The role of indirect effects on correlation value was also remarkable for NMC in the HS mating group (1.11 and –0.01, respectively). The negative indirect effects mainly through cane diameter, sucrose content

Table 3. Phenotypic path coefficient analysis of CCS yield and its primary components in three mating groups of sugarcane

Character	Group	NMC	Cane diameter	Cane length	Cane density	Brix %	Sucrose content	Phenotypic correlation with CCS/plot
NMC	HO	0.60	–0.15	–0.02	–0.01	–0.01	0.10	0.51
	HS	1.11	–0.65	–0.14	0.04	0.13	–0.50	–0.01
	HB	0.69	–0.31	–0.03	–0.05	–0.02	–0.12	0.16
Cane diameter	HO	–0.16	0.60	0.06	–0.27	0.00	–0.04	0.19
	HS	–0.89	0.81	0.12	–0.12	–0.11	0.45	0.26
	HB	–0.32	0.67	0.04	–0.19	0.01	0.09	0.30
Cane length	HO	–0.03	0.08	0.39	–0.00	0.00	–0.13	0.31
	HS	–0.36	0.22	0.44	–0.07	0.01	–0.00	0.24
	HB	–0.07	0.11	0.24	0.00	0.01	0.03	0.33
Cane density	HO	–0.01	–0.30	–0.00	0.53	0.00	–0.16	0.06
	HS	0.16	–0.33	–0.11	0.30	–0.07	0.17	0.12
	HB	–0.06	–0.25	0.00	0.52	0.01	0.04	0.26
Brix %	HO	0.10	–0.05	–0.05	–0.09	–0.03	0.67	0.55
	HS	–0.46	0.30	–0.01	0.06	–0.30	0.98	0.57
	HB	–0.15	0.09	0.03	0.07	0.09	0.48	0.61
Sucrose content	HO	0.09	–0.04	–0.07	–0.12	–0.03	0.70	0.53
	HS	–0.55	0.36	–0.00	0.05	–0.29	1.02	0.59
	HB	–0.17	0.12	0.01	0.04	0.09	0.50	0.59
Residual	HO	0.26						
	HS	0.48						
	HB	0.36						

and cane length were responsible for bringing down the correlation to a low level of –0.01. In such situations, the indirect causal factors are to be considered simultaneously for selection to increase efficiency of selection.

Even though the direct effect (1.02) of sucrose content was brought down to 0.59 for correlation, the higher direct effects of sucrose content and cane diameter on sugar yield would prove reliable for commercialisation of *S. spontaneum* hybrids through selection, keeping the NMC and cane length at moderate levels. The significant correlation coefficients for NMC and sucrose content (0.51 and 0.53, respectively) in the HO group and a lesser impact of indirect effects on direct effects attributed importance to these two traits for efficient selection. But cane diameter and cane length have to be kept at adequate levels, as these characters were negatively associated with both NMC and sucrose content. In the HB group, sucrose content was positively related to all the quantitative characters except NMC. Hence, selection in this group would be more efficient with emphasis on sucrose content with restricted simultaneous selection for NMC.

The residual effect determines how best the causal factors account for the variability of the dependent factor, namely, CCS per plot in the present case. Its estimates also varied in three mating groups. The highest proportion of unaccountable variability (48.0%) was in the HS group. The reason seems to be the low and nonsignificant correlations of quantitative characters with sugar yield. Besides, some other characters, which are not considered here, such as, extraction % and fibre content, need to be included in correlation and path analysis to account fully for the variation in sugar yield.

The previous studies emphasized the importance of the number of stalks as the most reliable character on which selection has to be based for a higher crop potential [2–5], whereas in this study, this character was important only in the HO mating group. This variation in the effective component together with deviation in the interrelationships between the component characters explains the role of the different species involved in the development of hybrid progenies. This may be due to the retention of the original species associations as reported by Brown et al. [12]. In this regard, the realistic relationship between the characters in different mating groups can act as a valuable aid in enhancing the efficiency of selection in sugarcane breeding aimed at maximising sugar productivity.

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