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GENETIC VARIATION AND NATURE OF CHARACTER ASSOCIATION IN SUGARCANE GERMPLASM

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ABSTRACT

A set of 65 sugarcane clones representing hybrid germplasm was evaluated for genetic variation, mean performance and character association. There was a large variation for cane yield brought about jointly by cane number, cane diameter and cane height. Variation for sucrose on the other hand was relatively low. Three clones, Co 7008, CoC 671 and Q 63 were found to be high sucrose types recording more than 20% sucrose at 12th month. Co 678, Co 62175, H 49-3533 and Co 7201 were found to possess high yield potential. Cane yield was positively associated with leaf area, internode number, internode length and cane diameter. Association of cane yield with cane number, on the other hand, was not significant. The association between cane yield and sucrose, although not significant, showed a negative trend, when very high yielders and very high sucrose type were considered.

In sugarcane breeding, *Saccharum ficinarum* and *S. spontaneum* and to a certain extent, *S. barberi* and *S. sinense* constitute the primary gene pool. Use of these species to build up a population showing commercially acceptable levels of cane yield and sucrose is a long drawn process. But once attained, it provides an impresive array of variability which forms the secondary gene pool. This hybrid germplasm, as it is often called, sustains the varietal evolution programmes. Sugarcane Breeding Institute, Coimbatore, being the apex institution for a varietal evolution, is vested with the responsibility of maintenance and replenishment of variability in hybrid germplasm apart from species germplasm. In the present study, representative samples of the hybrid germplasm maintained at this institute were evaluated.

MATERIALS AND METHODS

Sixty-five clones broadly representing the germplasm were studied in a randomized block design with three replications. Instead of the normal sett-planting, single budded setts were first planted in polythene bags containing soil-compost mixture and 60 days old settings were later transplanted in the main field. Each plot consisted of 15 settlings in three rows with a spacing of 90 cm between rows and 40 cm between settlings. Leaving guard rows on either side, the middle row were considered for collection of data on early tillers, leaf area, cane number, internode number, internode length, cane diameter, sucrose and cane yield. Data on early tillering were recorded at third month, whereas data on other characters were recorded at 12th month after planting.

Data processing for analysis of variance and covariance, estimation of coefficients of genetic determination and calculation of genotypic and phenotypic correlations was done with standard procedures.

RESULTS AND DISCUSSION

The results of analysis of variance are presented in Table 1. Clonal differences were highly significant for all the characters studied. Cane yield and sucrose content are the most important characters to be considered in sugarcane varietal development, since the final sugar yield is decided by these two characters. Cane yield showed the largest genotypic coefficient of variation (34%), while sucrose content recorded the lowest genotypic coefficient of variation (8%). This shows that while substantial improvement in cane yield could be achieved with the existing germplasm, improvement in quality could be only limited.

The large variation in cane yield was brought about jointly by considerable

Table 1. ANOVA and coefficients of genetic determination for yield and quality.

Character	Mean square			Genotypic coefficient of variation (%)	Phenotypic coefficient of variation	Coefficient of genetic determination
	Clones df = 64	Replications df = 2	Error df = 128			
Early tillers	11.48**	20.16**	2.84	24,60	34.66	0.50
Leaf area	15065**	61479**	1354	23.80	27.10	0.77
Cane number	18.35**	7.85	4.79	18.81	27.00	0.49
Internode number	30.19**	11.02	3.77	17.46	20.86	0.70
Internode length	8.87**	3.93*	0.98	13.54	15.86	0.73
Cane diameter	0.35**	0.13*	0.03	13.39	15.36	0.76
Sucrose percent	7.73**	5.44*	1.44	8.21	10.66	0.59
Cane yield	34.78**	18.48**	3.72	34.26	39.26	0.74

(represented in table 1 by its component characters internode number in internode length) and cane diameter. This clearly shows that improvement in cane yield will be possible only by judicial utilisation of the variation that exists in all these three component characters of cane yield.

Variation in early tiller number also was high, although it gradually diminished during cane formation stage, as revealed by the comparatively less variation in final cane number. This happens, because good proportion of tillers in low tillering clones emerge finally as millable canes as compared to high tillering clones. Most of the clones showing 10 more early tillers per plant as in the case of C or 1148, Co 1253, Co 62399, CoC 771 and B 37172 had a mean of only 3 to 4 tillers per plant at the time of harvest (Table 2) resulting in retention ratio of roughly 3 : 1. On the other hand, clones like Co 658, Co 798, Co 997 and CoC 671 that had less than 6 ttillers per plant at the early stage, tended to retain more than half the number at harvest. Hence, early tillering might not serve as an useful indicator of final cane number.

Coefficient of genetic determination was low for early tillers and cane number, moderate for sucrose and fairly high for leaf area, cane diameter, internode number, internode length and cane yield (Table 1). This shows that for most of the sugar yield traits, barring cane number, the error component can be considerably brought down through efficient experimentation, thus increasing reliability of selection.

The mean expression of clones for various traits along with general mean, standard error and critical differences are presented in Table 2. For early tillers, seven clones were superior to general mean and among them, Co 1148, Co 62399 and Co 7717 were outstanding. There were very large differences for leaf area in the materials tested. Out of 65 clones studied, 27 showed significantly higher leaf area than the general mean. CoC 775 and Co 658 were outstanding for this character. Co 285, Co 312, and CoJ 67 were superior to the general mean for cane number. Co 62174, Co 6804 and KHS 2045 recorded very low cane number. For internode number and internode length which are component characters of cane height, there were considerable differences. Eleven clones each for internode number and internode length were superior to general mean, Co 658, Co 1287, Co 1307, H 49-3533 and H 50-2606 being very tall clones. Cane diameter was another character showing considerable difference. Nine clones showed better expression compared to general mean and MS 68/47, Co 62174, Co 62175 and KHS 3296 were outstanding among them. BO 90,

Table 1. ANOVA and coefficients of genetic determination for yield and quality.

Clones	Early tillers per plant	Leaf area (cm^2)	Cane number per plant	Internode number per cane	Internode length (cm)	Cane diameter (cm)	Sucrose per cent	Cane yield (kg/plant)
1	2	3	4	5	6	7	8	9
Co 285	9.3	181	7.0	14.7	13.40	1.87	14.50	3.27
Co 312	8.3	187	5.7	15.0	13.47	2.10	16.23	3.44
Co 356	2.3	253	4.3	15.0	11.53	2.23	13.77	2.28
Co 419	7.3	267	4.4	16.3	11.87	2.67	17.57	3.64
Co 449	5.7	301	3.2	19.0	12.23	2.40	17.17	2.96
Co 453	7.7	302	3.9	15.3	14.17	2.40	15.87	3.29
Co 508	7.3	154	4.6	15.0	8.30	1.77	18.13	1.24
Co 527	8.3	247	4.3	14.7	11.23	2.33	17.67	2.38
Co 658	5.7	416	3.0	17.7	13.73	2.63	18.10	3.96
Co 678	8.0	316	4.2	12.3	13.80	2.63	15.30	6.31
Co 740	8.3	271	3.4	17.0	10.77	2.63	18.60	2.44
Co 775	6.7	375	3.8	15.0	12.93	2.43	17.17	3.12
Co 798	5.0	346	3.7	15.3	12.20	2.57	17.27	4.13
Co 997	5.7	368	4.1	18.0	10.57	2.37	19.10	3.37
Co 1007	5.0	319	4.1	15.3	12.17	2.03	18.03	2.58
Co 1148	12.0	266	3.7	12.7	13.67	2.13	15.87	2.36
Co 1158	9.0	227	4.8	15.0	11.43	2.17	16.03	2.38
Co 1253	10.0	261	3.3	12.3	13.67	2.33	16.17	3.02
Co 1287	7.7	265	3.2	17.7	14.53	2.67	16.77	4.24
Co 1307	5.7	297	3.0	19.3	13.07	2.63	14.03	3.66

1	2	3	4	5	6	7	8	9
Co 62174	7.3	325	2.6	22.3	10.33	3.03	19.60	3.39
Co 62175	6.7	279	4.0	23.0	10.13	3.00	16.27	5.84
Co 62198	8.7	266	4.4	11.7	15.30	2.20	17.47	2.48
Co 62399	10.7	244	4.4	15.3	9.77	2.03	16.03	1.76
Co 6304	6.3	317	3.3	17.7	13.57	2.77	17.17	4.34
Co 6804	5.3	271	2.6	18.7	10.80	2.50	16.30	2.53
Co 6806	9.3	294	4.9	14.3	12.90	2.37	19.20	2.94
Co 6907	8.3	166	3.7	16.0	8.63	2.20	18.27	1.57
Co 6914	4.0	149	2.9	16.7	9.00	2.40	18.00	1.44
Co 7006	6.0	337	3.2	16.3	11.83	2.23	18.60	2.16
Co 7008	8.7	334	4.0	16.7	11.93	2.13	20.97	2.89
Co 7201	7.0	377	4.9	16.3	14.30	2.33	17.73	5.00
Co 7219	5.0	259	3.8	17.3	12.03	2.57	19.67	3.49
Co 7313	5.3	302	3.7	18.7	12.23	2.60	18.53	4.08
Co 7314	8.3	263	4.0	15.0	13.27	2.13	19.20	2.62
Co 7701	6.7	261	3.6	15.3	9.73	2.80	17.97	2.10
Co 7704	6.3	324	3.2	17.0	12.47	2.87	19.67	3.11
Co 7717	10.7	331	4.3	15.3	12.47	2.60	18.73	3.66
CoA 7601	5.0	320	2.9	18.7	12.50	2.47	19.40	3.44
CoA 7602	5.7	322	4.3	14.0	16.10	2.60	19.47	3.59
CoA 771	10.3	187	4.9	15.0	10.53	1.93	19.27	2.34
CoC 671	4.7	354	2.7	15.0	12.43	2.67	21.50	2.99

1	2	3	4	5	6	7	8	9
CoC 771	10.0	375	3.7	15.0	14.50	2.23	17.20	3.1
CoC 773	5.7	358	2.9	16.3	11.93	2.53	18.80	2.4
CoC 775	6.0	473	3.8	17.0	15.17	2.30	19.90	4.3
CoJ 67	7.0	123	5.6	11.7	10.73	2.70	16.80	1.3
CoJ 72	6.3	307	4.1	15.3	13.93	2.63	18.27	3.4
BO 90	6.3	176	4.3	13.0	11.03	1.63	16.33	1.
BO 92	5.3	134	3.7	12.0	9.47	1.63	17.60	1.1
MS 68/47	5.3	382	3.3	14.7	12.67	3.43	16.33	4.8
KHS 2045	5.7	221	2.2	19.3	9.10	2.23	19.07	1.
KHS 3296	7.3	384	3.0	21.3	10.83	3.03	18.20	4.8
POJ 213	8.7	217	4.4	21.7	10.20	2.17	17.53	3.
POJ 2878	4.3	329	3.3	12.7	11.13	2.45	16.87	1.9
O 63	4.0	264	2.7	20.3	9.87	2.67	20.47	2.4
B 37172	10.0	318	3.4	21.7	11.50	2.30	18.77	3.
NCO 310	6.7	260	3.6	15.3	10.60	2.37	17.33	2.2
CP 44/101	5.0	188	3.2	15.0	12.40	2.20	15.07	2.
H 48-3116	7.0	237	3.4	21.3	11.37	2.47	19.23	3.
H 49-3533	4.3	320	3.8	16.7	14.13	2.70	16.80	5.
H 50-2606	4.7	320	3.3	26.0	11.13	2.33	15.07	4.2
H 50-7209	6.3	349	3.2	18.7	13.40	2.87	17.67	4.4
H 51-8194	9.0	296	3.0	21.0	11.57	2.33	17.33	2.7
H 52-723	8.0	228	4.4	22.7	10.70	2.27	16.50	4.6

1	2	3	4	5	6	7	8	9
H 54-5	5.3	288	3.0	22.7	10.30	2.43	17.87	2.67
General mean	6.9	284	3.8	17.0	11.98	2.41	17.65	3.13
SE	0.97	21.25	0.42	1.12	0.57	0.11	0.69	0.37
SE %	14.07	7.49	11.05	6.60	4.77	4.36	3.93	11.82
CD	2.73	59.50	1.18	3.14	1.60	0.29	1.94	1.04
CD %	39.39	20.96	31.05	18.49	13.55	12.22	10.99	33.22

BO 92, CoJ 67, Co 508 Co 285 and CoA 77-1 possessed very thin canes.

Seven clones recorded significantly superior sucrose % over general mean, the notable among them being CoC 671, Co 7008 and Q 63. Six clones, Co 856, Co 285, Co 678, Co 1307, CP 44/101 and H 50-2606 showed low sucrose content.

There were large differences for cane yield and 12 clones were significantly superior to general mean. Among the outstanding yielders, Co 678 recorded the highest yield followed by Co 62175, H 49-3533 and Co 7201. BO 90, BO 92, CoJ 67, Co 6914, Co 508, Co 6907, Co 62399, Co 7701, KHS 2045 and CP 44/101 were very poor yielders. The cane yield ranged from 3.13 kg in BO 90 to 18.93 kg in Co 678.

From the performance of individual clones, it appears that high cane yield and high sucrose content generally do not go together. Of the 65 clones tested, Co 678 was the highest yielder but low in sucrose content (Table 2). Other high yielders, which gave a cane yield of 15 kg or more per plot, had sucrose % values lower than the general mean. Clones rich in sucrose registered less quite below the general mean. The correlation between sucrose % and cane yield, although not significant (Table 3), showed a negative trend, when very high yielders and very high sucrose types were considered. A similar report of negative association between these two characters was made by Balasundaram and Bhagyalakshmi (1978), from their study on a set of 58 varieties representing Indian and exotic germplasm.

Genotypic and phenotypic correlation coefficients are presented in Table 3. There was not much difference between genotypic and phenotypic correlation coefficients. Cane yield at genotypic and phenotypic levels was positively and significantly correlated with leaf area, internode number, internode length and cane diameter.

Sucrose content in juice was positively correlated with leaf area and negatively correlated with cane number, the correlation coefficients being highly significant. Sucrose content did not show significant association with the other characters.

Leaf are was found to be positively related to internode number, internode length, cane di

Table3. Genotypic and Phenotypic correlations

Character	Leaf area	Cane number	Internode number	Internode length	Cane diameter	Sucrose per cent	Cane yield
Early tillers	a -0.1730	0.4835**	-0.1756	0.1276	-0.3007*	-0.0568	-0.0400
	b -0.1265	0.3462**	-0.1269	0.0893	-0.2215	-0.0237	-0.0097
		-0.4335**	0.2542*	0.5677**	0.6433**	0.3317**	0.6463**
Leaf area		-0.2616*	0.1909	0.4247**	0.4980**	0.1684	0.4909*
			-0.4748**	0.1964	-0.6018**	-0.3758**	-0.1292
Cane number			-0.2468*	0.1339	-0.3785**	-0.1778	0.1638
				-0.2009	0.4111**	0.0617	0.5506**
Internode number				-0.1224	0.3858**	0.0063	0.4962**
					0.2357	-0.1116	0.5442**
Internode length					0.1224	-0.0890	0.4217**
						0.1756	0..6777**
Cane diameter						0.1254	0.5542**
							-0.1171
Sucrose per cent							-0.0569

a = Genotypic correlation coefficients

b = Phenotypic correlation coefficients

addition to cane yield. Two other positive relationships noted were between (i) early tiller number and cane number and (ii) internode number and cane diameter.

Significant negative relationships were obtained between cane number on the one hand and leaf area, internode number, cane diameter and sucrose per cent on the other. Early tiller number also had numerically negative relationship with the above traits although the correlation coefficients were not significant in most cases.

Cane number appears to be one of the most import characters contributing towards cane yield in segregating populations as per earlier reports (George, 1962; James, 1971; Moriotti, 1971 and 1977 and skinner, 1982). However, in the materials studied, cane number was not associated with cane yield (Table 3) perhaps due to the reason that a number of clones showing extreme expressions for various characters get included in the germplasm. For instance, clones like Co 285, Co 312, Co 356, Co 508 Co 1148, Co 62399, CoA 771 and CoJ 67 were high tillering but low yielding clones. Similarly, Co 62175, Co 6304, MS 68/47, KHS 3296 and H 49-3533 were moderate tillering types, but high yielders. Thus, the correlation pattern presented in Table 3 appears to be a consequence of previous selection history, wherein individuals with extreme expressions for a single or a combination of characters have been prefered to others and hence might not represent the association pattern of traits in a segregating population.

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TOLERANCE OF RICE VARIETIES TO HIGH ACTIVE IRON CONTENT IN SOIL

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Tolerance of eight rice varieties to iron toxicity was studied. Tolerant varieties did not show symptoms of bronzing whereas, the sensitive varieties were severely affected. The tolerant varieties produced high straw and grain yield were observed to be associated with high nutrient ratios of N/Fe, P/Fe, K/Fe, Ca/Fe, Mg/Fe and Mn/Fe whereas the susceptible varieties were characterised by low nutrient ratios in the tissue and grain. Effective measures too ameliorate iron toxicity include liming, drainage and good fertilizer management. Tolerant rice varieties can serve as an alternative if iron toxicity is not severe.

Iron toxicity may be suspected when a reddish or brown scum of $Fe(OH)_3$ is visible on soil surface. It has been frequently observed with a pH less than 5.0 when dry (Van Mensvoort *et al.*, 1985). Most of the soils with typical iron toxicity problems poss a relatively low exchange capacity are characterised by relatively weak saturation with bases (Ca, Mg) and are undersupplied with P and K (Ottow *et al.*, 1983).

A large number of small brown spots appear on rice leaves affected by iron toxicity. Some varieties fail to show any discolouration but growth is retarded (Jayawardena *et al.*, 1977). Iron toxicity has been reported to occur at varying Fe levels but generally the symptoms appear at 300-500 ppm. Different varieties of rice show strikingly different capacity to tolerate stress conditions due to non-toxicity. It is expected that understanding, exploitation and deliberate manipulations of the heritable characters of rice genotypes would lead to high productivity. In view of this a field study was conducted to study the tolerance of rice cultivars to iron toxicity and the influence of iron toxicity on yield and uptake of nutrients.

MATERIALS AND METHODS

Typical iron toxic soil high in active iron (which builds Fe^{2+} about 400-500 ppm) was identified at Agricultural Research Station, Ponnampet. The selected experimental site represents a field situation of a low land surrounded by hills and was characterised by a oily looking scum floating on inundation water. The nursery of eight cultivars of rice namely Mahsuri, SPM, Siyam Halas, Siyam Kuning, CSR4, Intan Gowri, Getu and Damodar was raised on sand/solution culture media. Twenty two day old seedlings were transplanted in the typical iron toxic soil. The varieties were replicated four times. All the intercultural operations and plant protection and fetilizer application schedules were adopted as per package of practices of the crop as and when necessary. The plant

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