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STUDIES ON GENETIC VRIABILITY PARAMETERS, CHARACTER ASSOCIATION AND PATH ANALYSIS AMONG YIELD AND YIELD CONTRIBUTING TRAITS IN SUGARCANE (*SACCHARUM OFFICINARUM* L.)

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ABSTRACT
An investigation was carried out to study the genetic variability, association among the yield component traits, their direct and indirect effects on the yield. All the genotypes showed considerable amount of variation in their mean performances with respect to the characters studied, indicates presence of sufficient variability and scope for further selection and breeding superior and desirable genotypes Genotypic coefficient of variation played a major role for the expression of the traits and ranged from 3.08 (purity) to 27.44 (single cane yield). Heritability in narrow sense ranged from 44.00 (purity) to 89.00 (single cane yield). High genetic advance was observed for the trait, cane yield (63.61) coupled with high heritability (89), indicating the preponderance of the non-additive gene action; suggesting that hybridization breeding will be effective. No. of Internodes (0.603, 0.542) ,Girth of internodes (0.780, 0.671) and single cane yield (0.847,0.793) were positively associated with cane yield/Ha at both genotypic and phenotypic levels respectively, indicating improvement in these traits will increase the cane yield. Number of internodes(1.00, 0.14, intermodal length (0.71, 0.05) and single cane yield (0.831,0.681) had positive direct effect on yield at both genotypic and phenotypic levels respectively, indicating importance of these characters and which can be strategically used to improve the yield of sugarcane

INTRODUCTION

Sugarcane is an important commercial crop and is a source of food, fuel, fodder and fibre. Karnataka state ranks third in sugarcane area and production. It is cultivated predominantly as an annual irrigated crop in India. Sugarcane is favourably adaptable to a wide range of agricultural situations, but its productivity is generally limited by biotic and abiotic stresses. Northern parts of Karnataka has major stake in respect of area and production. Though this part of the state is top in the country for sugar recovery, as it is favoured with cold and dry winter coinciding cane ripening (crushing) season, but the cane productivity levels are lower compared to southern Karnataka, because of monoculture of sugarcane varieties over large diverse and adverse agro-ecologies *viz*., drought, salinity, water logging and normal irrigated environment. In addition, popular varieties have drawbacks like moderate ratooning ability and susceptibility to abiotic stresses *viz*., drought and salinity water logging etc. Therefore, development and adoption of location specific varieties to respond well under favourable conditions and to withstand specific stress could be an ideal approach.

Progress in improvement of a crop or crop variety depends on the degree of variability in the desired character in the base material. For assessing the feasibility of joint selection of two or more traits, study of relationships among quantitative traits is important and also to evaluate the effect of selection for secondary traits on genetic gain for the primary trait under consideration. A positive genetic correlation between two desirable traits makes the job of the plant breeder easy for improving both traits simultaneously. Path coefficient analysis was performed to qualify the direct and indirect contributors of yield components and developmental traits of fodder yield. Therefore the present investigation was carried out to study the genetic variability, relationships among quantitative traits and Path coefficient analysis in selected genotypes of sugarcane

MATERIALS AND METHODS

Twenty Eight genotypes, viz., CO-209,COM-9902,CO-302,CO-308,CO-310,CO-312,CO-314,SNK-825,SNK-49,SNK-632,SNK-44,CO-94012,CO-211,CO-212,CO-218,CO-320,COM-265,SNK-432,CO-2001-13,CO-2001-15,COM-9602,CO-99006,CO-99004,SNK-814,SNK-349 and CO-86032 were planted in a triplicate RCBD under field conditions. Each variety was accommodated in a plot having six (6) rows of four (4) meter lengths with row to row spacing 90cm. All the agronomic practices were kept normal for all the twenty eight genotypes. Five guarded plants from each genotypes and replication were randomly selected for recording data on average height of 5 canes (m), millable cane height (m), number of internodes, girth of inter node (cm),

Table 1: Mean sum of squares for characters in sugarcane

Characters	Replication	Genotypes	Error	S.Em.±	CV (%)
Germination percentage	11.16	118.12**	9.86	2.56	4.37
Avg. Height of 5 canes (m)	0.06	0.34**	0.05	0.19	6.83
Millable cane height (m)	0.05	0.30**	0.02	0.11	5.95
No. of internodes	1.94	14.49**	0.98	0.81	4.6
Girth of internode (cm)	0.49	2.39**	0.15	0.32	4.18
Internodal length (cm)	1.04	4.37**	0.27	0.42	4.59
Brix %	0.24	2.42**	0.59	0.63	3.7
Polarity	0.27	2.83**	0.79	0.73	4.73
Purity	1.75	32.90**	9.89	2.57	3.49
Single cane yield (kg)	0.01	0.40**	0.02	0.12	11.19
Cane Yield /Ha(ton)	147.81	3363.51**	137.44	9.57	9.73

Table 2: Mean and other variability parameters for characters in sugarcane

Characters	Mean	Range		GCV	PCV	h^2	GA	GAM
		Min	Max					
Germination percentage	71.91	50	82	8.35	9.43	79	10.97	15.26
Avg. Height of 5 canes (m)	3.38	2.5	4.26	9.22	11.47	65	0.51	15.11
Millable cane height (m)	2.32	1.8	3.6	13.21	14.49	83	0.58	24.95
No. of internodes	21.53	16.4	28	9.86	10.88	82	3.96	18.39
Girth of internode (cm)	9.37	6.75	11.83	9.22	10.12	83	1.62	17.28
Internodal length (cm)	11.24	9.1	14.25	10.41	11.38	84	2.21	19.67
Brix %	20.75	18.02	22.81	3.77	5.28	51	1.15	5.54
Polarity	18.8	15.99	21.45	4.39	6.45	46	1.15	6.12
Purity	90.01	79.36	99.56	3.08	4.66	44	3.77	4.19
Single cane yield (kg)	1.3	0.8	2.6	27.44	29.63	86	0.68	52.41
Cane Yield /Ha(ton)	120.48	56.66	211.11	27.22	28.9	89	63.61	52.8

inter nodal length (cm), brix %, polarity, purity, and single cane yield (kg) and observation was also recorded on germination percentage and cane yield /ha(ton) . The data was analyzed statistically for genotype and phenotype coefficients of variation (Burton, 1952) , Heritability (Allard, 1960) and genetic advance (Johnson, *et al.*, 1955). The genotypic and phenotypic correlation co-efficient, path co-efficient analysis was done to partition the genotypic correlation co-efficient into direct and indirect effects. Association among the characters is useful in formulation of breeding programme aimed at achieving the desired combinations of various components of yield and also and help to differentiate vital associations useful in breeding from those of the non-vital ones (Falconer, 1981).

RESULTS AND DISCUSSION

Mean sum of squares ,error and coefficient of variation (%) for all the characters studied are presented in Table 1.All most all the genotypes showed considerable amount of differences or variation in their mean performances with respect to the characters studied. This indicates that there is presence of sufficient variability for the characters in the genotypes studied indicating scope for further selection and breeding superior and desirable genotypes or varieties. Similar results were observed by Farooq Ahmad Khan *et al.* (2007) and Rewati *et al.* (2005).

The results of estimates of genetic variability, heritability, genetic advance for grain yield per plant and other characters are presented in Table 2. The PCV was higher than GCV for all the characters studied showing that all the traits were highly influenced by environment. However differences between them were not of high magnitude. High estimates of genotypic and phenotypic coefficient of variation were observed for cane yield per hectare (27.22, 29.63) and single cane yield (27.44, 28.9). Low GCV and PCV were noticed for brix % (3.77, 5.28), purity (3.08, 4.66) and polarity (4.39, 6.45).

The effectiveness of selection for any character depends not only the extent of genetic variability but also in the extent to which it will be transferred from one generation to the other generation. High heritability was observed for cane yield /ha (89), single cane yield (86), inter nodal length (84) girth of inter node and millable cane height (83) and number of internodes (82). However brix %, polarity, purity, recorded low heritability in the present study. High and low genetic advance was observed for cane yield per hectare (63.61) and average height of 5 canes (0.51). High heritability coupled with high genetic advance was recorded for cane yield per hectare, revealing that character is governed by additive gene action and phenotypic selection for these characters will be effective.

Correlation coefficient is a statistical measure, which denotes the degree and magnitude of association between any two casually related variables. This association is due to pleitropic gene action or linkage or more likely both. In plant breeding correlation coefficient analysis measures the mutual relationship between two characters and it determines character association for improvement yield and other economic characters. Since the association pattern among yield components help to select the superior genotypes from divergent population based on more than one interrelated characters. Thus information on the degree and magnitude of

Table 3: Phenotypic and genotypic correlation coefficient between different traits in sugarcane

Characters		Germination percentage	Avg. Height of 5 canes (mtr)	Millable cane height (mtr)	No. of internodes	Girth of internode (cms)	Internodal length (cms)	Brix %	Polarity	Purity	Single cane yield (kg)	Cane Yield/ Ha(ton)
Germination percentage	G	1	-0.042	-0.293	-0.21	-0.266	-0.024	0.489*	0.402	0.064	-0.346	-0.385
	P		-0.029	-0.255	-0.169	-0.186	-0.033	0.264	0.194	0.022	-0.263	-0.297
Avg. Height of 5 canes (mtr)	G		1	0.429*	-0.099	0.416*	0.516**	0.06	-0.112	-0.26	0.362	0.204
	P			0.385	-0.189	0.2	0.470*	-0.048	-0.107	-0.123	0.228	0.108
Millable cane height (mtr)	G			1	0.148	0.317	0.505**	-0.311	-0.357	-0.224	0.379	0.291
	P				0.146	0.268	0.461*	-0.213	-0.262	-0.147	0.324	0.221
No. of internodes	G				1	0.502**	-0.529**	-0.572**	-0.348	0.268	0.576**	0.603**
	P					0.466*	-0.516**	-0.296	-0.192	0.111	0.568**	0.542**
Girth of internode(cms)	G					1	0.092	-0.212	0.074	0.273	0.802**	0.780**
	P						0.081	-0.037	0.124	0.159	0.701**	0.671**
Internodal length(cms)	G						1	0.046	-0.152	-0.322	0.036	-0.05
	P							-0.022	-0.09	-0.12	-0.052	-0.097
Brix %	G							1	0.738**	-0.307	-0.262	-0.223
	P								0.654**	-0.207	-0.129	-0.135
Polarity	G								1	0.420*	-0.222	0.077
	P									0.528**	-0.134	0.096
Purity	G									1	-0.059	0.266
	P										-0.07	0.223
Single cane yield (kg)	G										1	0.847**
	P											0.793**
Cane Yield/Ha(ton)	G											1
	P											

Table 4: Genotypic and phenotypic path analysis for direct (diagonal) and indirect (off diagonal) effects of yield components on yield in sugarcane

Characters		Germination Percentage	Avg. Height of5 canes (mtr)	Millable caneheight (mtr)	No. of internodes	Girth of internode (cms)	Internodal length(cms)	Brix %	Polarity	Purity	Single cane yield (kg)	Cane Yield/ Ha(ton)
Germination percentage	G	-0.546	0.01	0.01	-0.21	0.16	-0.02	0.54	-0.09	0.057	-0.287	-0.385
	P	-0.103	0.13	0.03	-0.02	-0.01	0.01	-0.05	0.06	0.001	-0.179	-0.297
Avg. Height of5 canes (mtr)	G	0.023	0.02	-0.02	-0.1	-0.24	0.36	0.07	0.03	-0.233	0.301	0.205
	P	0.003	-0.02	-0.01	-0.03	0.01	0.02	0.01	-0.03	-0.005	0.155	0.107
Millable Cane height (mtr)	G	0.16	0.01	-0.05	0.15	-0.19	0.36	-0.34	0.08	-0.201	0.315	0.293
	P	0.026	-0.01	-0.03	0.02	0.02	0.02	0.04	-0.08	-0.006	0.22	0.22
No. ofinternodes	G	0.115	0.07	-0.01	1	-0.3	-0.37	-0.63	0.08	0.241	0.479	0.603**
	P	0.017	0.03	0.01	0.14	0.03	-0.03	0.06	-0.06	0.004	0.386	0.542**
Girth ofinternode(cms)	G	0.145	0.01	-0.01	0.5	-0.59	0.07	-0.23	-0.02	0.245	0.667	0.780**
	P	0.019	0.07	-0.01	0.06	0.07	0.07	0.01	0.04	0.006	0.477	0.671**
Internodallength(cms)	G	0.013	0.01	-0.02	-0.53	-0.05	0.71	0.05	0.03	-0.289	0.03	-0.051
	P	0.003	-0.01	-0.01	-0.07	0.01	0.05	0	-0.03	-0.005	-0.035	-0.098
Brix %	G	-0.267	0.03	0.01	-0.57	0.12	0.03	1	-0.17	-0.276	-0.218	-0.223
	P	-0.027	0.12	0.01	-0.04	0.07	0	-0.19	0.21	-0.008	-0.087	-0.134
Polarity	G	-0.22	0.03	0.02	-0.35	-0.04	-0.11	0.81	-0.22	0.377	-0.185	0.077
	P	-0.02	0.12	0.01	-0.03	0.01	-0.01	-0.12	0.32	0.021	-0.091	0.095
Purity	G	-0.035	-0.01	0.01	0.27	-0.16	-0.23	-0.34	-0.09	0.897	-0.049	0.266
	P	-0.002	0.03	0.01	0.02	0.01	-0.01	0.04	0.17	0.04	-0.048	0.224
Single caneyield (kg)	G	0.189	0.01	-0.02	0.57	-0.47	0.03	-0.29	0.05	-0.053	0.831	0.847**
	P	0.027	-0.01	-0.01	0.08	0.05	0.07	0.02	-0.04	-0.003	0.681	0.793**

association between characters is of prime important for the breeder to initiate any selection plan. In general the genotypic correlation was generally of higher magnitude than phenotypic correlation (Table 3), indicating that inherent association between various characters studied.

Germination percentage was positively associated brix percent (0.489*). Average height of 5 canes was positively and significantly associated with millable cane height (0.429*), girth of internode (0.416*) and inter nodal length (0.516*) (Gana *et al*., 2009). There was positive and significant correlations were noticed between millable cane height and inter nodal length (0.505*) (Farooq Ahmad Khan, *et al* ,(2007)), girth of internode with single cane yield(0.802**)(Imtiaz Ahmed Khan, *et al*., 2012) and cane yield per hectare (0.780**),number of inter nodes with inter nodal girth (0.502**) (Rewati *et al*., 2005), single cane yield (0.576**) and cane yield per hectare(0.603*) ,but the character was negatively associated with inter nodal length (-0.529**) and brix (-0.572**). Brix percent, polarity and single cane yield were positively associated with polarity (0.738**), purity (0.420*) and cane yield per hectare (0.847**) respectively. (Abdelmahmoud O. Ahmed and Ahmed Obeid, 2012).

Millable cane height showed positive association with inter nodal length (0.461*),number of inter nodes was positively associated with single cane yield (0.568**) and cane yield per hectare (0.542**) but negatively with inter nodal length (-0.516**).There was positive and significant association between number of internodes and single cane yield (0.701**) and cane yield per hectare (0.671**).Brix percent, polarity and single cane yield were positively associated with polarity (0.654**), purity (0.528**) and cane yield per hectare (0.793**) respectively.(Abdelmahmoud O. Ahmed and Ahmed Obeid, 2012).

Due to mutual cancellation of component traits, the estimation of correlation alone may be often misleading so it is necessary to study the path co-efficient analysis which takes into account the casual relationship in addition to the degree of relationship. Hence genotypic and phenotypic correlation was partitioned into direct and indirect effects to know the relative importance of the components (Table 4). No. of internodes, internodal length, purity and single cane yield had positive direct effect on cane yield per hectare at both genotypic and phenotypic level indicating importance of these characters.

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