RESEARCH ARTICLE

ASSESSMENT OF GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS FOR CANE YIELD WITH ITS COMPONENT TRAITS IN EARLY MATURING SUGARCANE CLONES

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Received-01.06.2021, Revised-11.06.2021, Accepted-21.06.2021

Abstract: Twenty five early maturing sugarcane clones were evaluated in randomized block design with three replications at research farm of CCS Haryana Agricultural University, Regional Research Station, Uchani, Karnal during *spring season*, 2020-21. The objective of the investigation was to study genetic variability, correlation and path analysis for seventeen characters among twenty five diverse early maturing sugarcane clones. Significant differences were observed among the genotypes for all the characters studied. The higher magnitude of genotypic (GCV) and phenotypic coefficients of variation (PCV) was recorded for traits like number of tillers at 120 DAP, single cane weight, cane length, CCS (t/ha) and cane yield. High heritability coupled with high genetic advance as percentage of mean was recorded for number of tillers at 120DAP, single cane weight, cane length, CCS (t/ha) and cane yield suggesting preponderance of additive gene action in the expression of these characters. Cane yield showed significant and positive correlation with number of tillers at 120DAP, number of shoots at 240DAP, number of millable canes at harvest, single cane weight, cane length, cane girth and CCS (t/ha.) at both genotypic and phenotypic level.Path analysis revealed that sucrose % at 8 months showed highest positive direct effect on cane yield followed by CCS % at 10 months, CCS (t/ha), single cane weight, number of millablecanes at harvest, purity % at 8 months and number of tillers at 120DAP.These characters merit special attention in formulating selection strategy in sugarcane for developing high yielding and early maturing sugarcane clones.

Keywords: Sugarcane, Genetic variability, Heritability, Correlation, Path coefficient analysis

INTRODUCTION

Sugarcane (*Saccharum* spp. Complex) is an important cash crop of the country next to cotton. India has emerged as the largest producer of sugar in the world. It is widely grown in tropics and subtropics as a source of energy providing food, fuel and feed and also contributes 75 % of the total world sugar (Kumar *et al.*2013).It is cultivated in most of the states of India with total area of 4.86million hectare with average productivity of 77.6 tons per hectare. Sugarcane was cultivated in 0.11million hectare area with average cane yield of 80.65 tons per hectare during 2019-20 in Haryana (Anonymous, 2020). The extent of genetic variability has been considered as an important factor which is an essential pre-requisite for successful hybridization aimed to produce high yielding sugarcane clones. The selection becomes difficult if the improvement is made for a polygenetically controlled complex character like cane yield. It is also widely recognized that genetic architecture of yield can be resolved by studying its component characters. This enables the breeder to breed for high yielding sugarcane clones with desired combinations of characters. The heterozygous and polyploidy nature of this crop has resulted in generation of greater genetic variability. The information on the nature and magnitude of variability present in the genetic material is of great importance for a breeder to initiate any effective selection programme. Genotypic and Phenotypic co-efficient of variation along with heritability and genetic advance are essential to improve any sugarcane trait and would help to know whether or not the desired objective can be achieved from the material (Tyagi and Singh, 1998).

The knowledge of interrelationship among various traits can be of immense help to the plant breeder for making effective selection. Correlation studies along with path analysis provide a better understanding of the association of different traits with cane yield. Correlation is useful in disclosing the magnitude and direction of the relationship between various yield contributing traits and yield. Path Coefficient or standardized partial regression coefficient measures the direct effect of a predictor variable upon its response variable and the second component being the indirect effect(s) of a predictor variable (Dewey and Lu, 1959). Therefore, field experiment was carried out to study the extent of genetic variability, correlation and path coefficient in sugarcane for cane yield and associated traits.

MATERIALS AND METHODS

The experiment material for the present study consists of twenty five early maturing sugarcane clones evaluated in randomized block design with three replications, each genotype planted in four rows of six meter length with plot size of 21.6 m^2 during *spring*, 2020 at CCS Haryana Agricultural University, Regional Research Station, Uchani,

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Karnal. The growth characters viz., number of tillers at 120 days after planting (DAP), number of shoots at 240days after planting (DAP), number of millable canes (000/ha) and cane yield (t/ha) at harvest were recorded on plot basis. The observations were recorded on five randomly tagged plants for single cane weight (kg), cane length cm), cane diameter (cm), extraction %. Quality characters like Brix, sucrose, purity and CCS % were recorded at 8 and 10 months, respectively. Analysis of variance was carried out for partitioning the total variation due to treatments and replications according to the procedure given by Panse and Sukhatme (1967). PCV and GCV were calculated by the formula given by Burton (1952), heritability in broad sense (h^2) by Burton and De Vane (1953) and genetic advance was calculated by using the procedure given by Johnson *et al.* (1955). Correlation coefficient and path coefficient were worked out as method suggested by Al Jibouri *et al.* (1958) and Dewey and Lu (1959), respectively. The estimated values were compared with table values of correlation coefficient to test the significance of correlation coefficient prescribed by Fisher and Yates (1967).

RESULTS AND DISCUSSION

The mean squares for the characters studied (Table 1) revealed that mean sum of squares due to genotypes were highly significant for all the characters. This suggests that the genotypes selected were genetically variable and considerable amount of variability existed among them. The development of an effective plant breeding programme depends on the existence of genetic variability. The variability among genotypes indicates ample scope for selection of different quantitative characters for sugarcane improvement. The variability parameters obtained from the data are presented in Table 2. The higher magnitude of genotypic (GCV) and phenotypic coefficients of variation (PCV) was recorded for traits namely number of tillers at 120 DAP, single cane weight, cane length, CCS (t/ha) and cane yield. This indicates the presence of wide genetic variability and possibility of genetic improvement through direct selection of these traits. The moderate estimates were observed for number of shoots at 240DAP, sucrose and CCS % at 8 months which suggests that there is scope for improvement of these traits. The lower estimates of PCV and GCV for the traits viz., cane girth, brix and purity % at 8 months, brix, sucrose, purity, CCS % at 10 months and extraction % at harvest reveals the existence of narrow range of variability and little scope for direct selection of these traits.

Heritability of any trait of interest determines the success of selection for its improvement. Among the morphological traits studied (Table 2), high heritability was observed for traits like; cane length (91.76%), single cane weight (91.53%), cane yield (87.69%),CCS (t/ha) (84.68%) and number of tillers at 120DAP (82.97%) whereas among the quality characters sucrose (97.42%), CCS(96.68%) and brix (96.60%) at 8 months and brix (92.95%),sucrose % (92.94%) and CCS (90.40%) at 10 months showed high heritability values. This indicates the predominant genetic influence in the inheritance of the traits and hence selection for improvement of the traits could be effective. This is in accordance with the findings of Ahmed *et al.* (2019). Based on this consideration high heritability coupled with high genetic advance as percentage of mean was recorded for number of tillers at 120DAP, single cane weight, cane length, CCS (t/ha) and cane yield suggesting preponderance of additive gene action in the expression of these characters. Therefore, selection may be effective through these characters. High heritability associated with moderate genetic advance as percentage of mean was observed for brix and sucrose % at 8 months and brix and CCS % at 10 months whereas, cane girth and purity % at 8 months recorded high heritability and low genetic advance as percentage mean which revealed the non-additive gene action in the expression of these characters, hence in this case selection may not be effective. These findings were in agreement with the findings of Sanghera *et al.* (2018) and Kumari*et al.* (2020).

The estimates of correlation coefficients (Table 3) revealed that genotypic and the phenotypic correlation coefficients showed similar trend but genotypic correlation coefficients were of higher in magnitude than corresponding phenotypic correlation coefficients which can be due to masking or modifying effect of environment. The cane yield showed significant and positive correlation with number of tillers at 120DAP (r=0.470), number of shoots at 240DAP (0.488), number of millable canes at harvest (0.709), single cane weight (0.940), cane length (0.475), cane girth (0.543) and CCS (t/ha,0.922)at both genotypic and phenotypic level. Therefore, selection on the basis of above characters would be reliable. Parihar (2020) also reported that cane yield has significant and positive correlation with number of tillers, number of millable canes, cane length, cane girth and single cane weight.

Path Coefficient analysis is an important tool for partitioning the correlation coefficients into the direct and indirect effects of independent variables on a dependent variable. With the inclusion of more variables in correlation study, their indirect association becomes more complex. Two characters may show correlation, just because they are correlated with a common third one. In such circumstances, path coefficient analysis provides an effective means of a critical examination of specific forces action to produce a given correlation and measure the relative importance of each factor. In this study, cane yield was taken as dependent variable and rest of the characters were considered as independent variables. The path coefficient analysis splits total correlation coefficient of different characters into direct and indirect effects on cane yield in such a manner that the sum of direct and indirect effects is equal to total correlation (Table 4). The path analysis revealed that sucrose % at 8 months (1.744) showed highest positive direct effect on cane yield followed by CCS % at 10 months (1.638), CCS (t/ha,0.890), single cane weight(0.053), number of millable canes at harvest (0.041), purity % at 8 months (0.011). Therefore, these traits may be considered as principal traits while selecting for cane yield. The quality characters like sucrose % and CCS % at 8 months also had direct effect on cane yield. This may be due to selection of new early clones over best standard Co 0238 for both cane yield and sucrose content. The positive indirect effect of number of tillers at 120 DAP through number of millable canes at harvest, single cane weight, cane girth, CCS (t/ha), CCS % at 8 months, brix, sucrose and purity % at 10 months was observed. Number of millable canes at harvest exhibited higher positive indirect effect on cane yield through CCS (t/ha), number of tillers at 120 DAP, single cane weight, sucrose % at 8 months, brix, sucrose and purity % at 10 months. Single cane weight exhibited high indirect effect through CCS (t/ha), number of tillers at 120DAP, number of millable canes at harvest, sucrose % at 8 months, brix, sucrose and purity % at 10 months. These results are in agreement with earlier findings of Gowda and Saravnam (2016) and Viradiya *et al.* (2016).

On the basis of above this study, it may be stated that CCS (t/ha), single cane weight, number of tillers at 120 DAP and number of millable canes at harvest are most important morphological characters for cane yield whereas among the quality parameters CCS % at 10 months, sucrose % at 8 months, brix, sucrose and purity % at 10 months also contributes to cane yield. Path coefficient results showed the amount of contribution either directly or indirectly and also the percentage of each parameter to the cane yield. It can be concluded that CCS (t/ha), single cane weight, number of tillers at 120 DAP and number of millable canes at harvest exhibited the highest contribution to cane yield. Therefore, these parameters are very important to be considered when selecting for sugarcane yield especially in determining possibility of obtaining yield from millable sugarcane particularly for subtropical ecology. Cane yield is associated with various morphological and quality components their heritability, expected genetic advance that could be encountered within the sugarcane breeding programme.

Table 1. Analysis of Variance for yield and quality characters in Sugarcane clones

S. No.	Characters	Mean sum of squares		
		Replications(df : 2)	Treatments(df : 28)	Error(df : 48)
1	**No. of Tillers at 120 DAP**	373.069	2252.203**	144.215
2	**No. of Shoots at 240 DAP**	177.889	409.137**	82.343
3	**No. of Millable canes at harvest**	143.66	175.745**	40.325
4	**Single cane weight (kg)**	0.001	0.034**	0.001
5	**Cane length(cm)**	33.754	2018.961**	58.696
6	**Cane Girth (cm)**	0.007	0.056**	0.005
7	**CCS (T/Ha.)**	1.244	8.88**	0.505
8	**Brix % (8M)**	0.031	5.286**	0.061
9	**Pol % (8M)**	0.12	5.633**	0.049
10	**Purity% (8M)**	0.55	13.081**	1.057
11	**CCS % (8M)**	0.091	3.188**	0.036
12	**Brix % (10M)**	0.194	2.409**	0.059
13	**Pol % (10M)**	0.041	2.554**	0.063
14	**Purity % (10M)**	1.449	5.587**	1.093
15	**CCS % (10M)**	0.017	1.445**	0.049
16	**Extraction %**	21.813	26.314**	5.222
17	**Cane Yield (T/Ha.)**	81.634	652.305**	29.173

** Significant at 1% level

Table 2. Genetic variability parameters for different characters in Sugarcane

S. No.	Characters	Mean	Range		Coefficient of Variation		Heritability (%)	Genetic Advance (%)	Genetic Advance as per cent of mean
			Max.	Min.	Genotypic (%)	Phenotypic (%)			
1	**No. of Tillers at 120 days**	150.96	199.75	100.55	17.56	19.28	82.97	49.74	32.95
2	**No. of Shoots at 240 days**	117.68	151.15	96.90	8.87	11.75	56.95	16.23	13.79
3	**No. of Millable canes at Harvest**	106.69	119.30	92.93	6.30	8.67	52.82	10.06	9.43
4	**Single cane weight (kg)**	0.86	1.13	0.69	12.12	12.67	91.53	0.21	23.89
5	**Cane length (cm)**	209.73	255.07	149.73	12.19	12.72	91.76	50.44	24.05
6	**Cane Girth (cm)**	2.54	2.85	2.29	5.14	5.86	77.08	0.24	9.30
7	**CCS (t/ha)**	11.03	14.03	8.31	15.15	16.47	84.68	3.17	28.73
8	**Brix % (8M)**	18.79	22.03	16.43	7.02	7.15	96.60	2.67	14.22
9	**Pol % (8M)**	16.44	19.45	14.04	8.30	8.41	97.42	2.77	16.87
10	**Purity% (8M)**	87.41	90.14	82.15	2.29	2.58	79.14	3.67	4.20
11	**CCS % (8M)**	11.32	13.44	9.55	9.06	9.21	96.68	2.08	18.35
12	**Brix % (10M)**	20.31	22.50	17.73	4.36	4.52	92.95	1.76	8.66
13	**Pol % (10M)**	17.85	19.68	14.86	5.11	5.30	92.94	1.81	10.14
14	**Purity % (10M)**	87.87	90.09	83.78	1.39	1.83	57.81	1.92	2.18
15	**CCS % (10M)**	12.31	13.55	10.01	5.54	5.83	90.40	1.34	10.85
16	**Extraction %**	57.62	69.82	53.36	4.60	6.08	57.38	4.14	7.18
17	**Cane Yield (t/ha)**	89.80	113.91	68.42	16.05	17.14	87.69	27.80	30.96

Table 3. Estimates of genotypic (upper) and phenotypic (lower) correlation coefficients among different characters in sugarcane

Characters		No. of Shoots at 240 days	No. of Millable canes at Harvest	Single cane wt. (Kg)	Cane length (cm)	Cane Girth (cm)	CCS (t/ha.)	Brix % (8M)	Pol % (8M)	Purity% (8M)	CCS % (8M)	Brix % (10M)	Pol % (10M)	Purity % (10M)	CCS % (10M)	Extraction %	Cane Yield (t/ha)
No. of Tillers at 120 days	rg	0.808**	0.797**	0.288*	0.530**	-0.146	0.490**	0.027	-0.013	-0.105	-0.028	0.024	-0.031	-0.179	-0.053	0.005	0.470**
	rp	0.694**	0.653**	0.234*	0.465**	-0.05	0.445**	0.032	-0.017	-0.123	-0.035	-0.028	-0.054	-0.082	-0.063	-0.018	0.443**
No. of Shoots at 240 days	rg		0.872**	0.265*	0.418**	-0.239*	0.557**	0.178	0.183	0.114	0.181	0.142	0.087	-0.125	0.065	0.032	0.488**
	rp		0.771**	0.171	0.274*	-0.128	0.485**	0.149	0.123	0.005	0.111	0.048	0.032	-0.027	0.025	-0.061	0.450**
No. of Millable canes at Harvest	rg			0.461**	0.611**	0.109	0.695**	0.038	0.053	0.078	0.058	-0.086	-0.155	-0.313**	-0.18	0.049	0.709**
	rp			0.287*	0.399**	0.065	0.649**	0.041	0.032	0.004	0.029	-0.101	-0.124	-0.115	-0.13	0.001	0.667**
Single cane weight	rg				0.407**	0.631**	0.877**	0.17	0.09	-0.221	0.058	-0.171	-0.250*	-0.406**	-0.276*	0.077	0.940**

(Kg)																	
	rp				0.396**	0.533**	0.816**	0.155	0.081	-0.18	0.052	-0.135	-0.223	-0.330**	-0.249*	0.086	0.881**
Cane length (cm)	**rg**					0.156	0.451**	-0.075	-0.111	-0.153	-0.122	-0.155	-0.134	-0.019	-0.125	0.382**	0.475**
	rp					0.164	0.404**	-0.073	-0.102	-0.121	-0.111	-0.148	-0.136	-0.035	-0.128	0.302**	0.437**
Cane Girth (cm)	**rg**						0.321**	-0.339**	-0.344**	-0.213	-0.341**	-0.599**	-0.622**	-0.451**	-0.622**	0.132	0.543**
	rp						0.265*	-0.288*	-0.303**	-0.178	-0.302**	-0.498**	-0.526**	-0.321**	-0.522**	0.029	0.452**
CCS (t/ha.)	**rg**							0.410**	0.357**	0.015	0.332**	0.169	0.081	-0.234*	0.047	-0.071	0.922**
	rp							0.367**	0.318**	0.016	0.293**	0.161	0.11	-0.083	0.088	-0.037	0.925**
Brix % (8M)	**rg**								0.969**	0.432**	0.943**	0.793**	0.674**	0.012	0.620**	-0.239*	0.152
	rp								0.959**	0.344**	0.923**	0.752**	0.640**	0.014	0.582**	-0.171	0.137
Pol % (8M)	**rg**									0.639**	0.996**	0.816**	0.730**	0.146	0.687**	-0.327**	0.077
	rp									0.592**	0.994**	0.775**	0.697**	0.121	0.649**	-0.208	0.064
Purity% (8M)	**rg**										0.707**	0.522**	0.580**	0.513**	0.594**	-0.460**	-0.212
	rp										0.673**	0.447**	0.510**	0.383**	0.520**	-0.22	-0.18
CCS % (8M)	**rg**											0.812**	0.739**	0.194	0.702**	-0.354**	0.047
	rp											0.767**	0.703**	0.158	0.661**	-0.217	0.035
Brix % (10M)	**rg**												0.973**	0.487**	0.950**	-0.438**	-0.202
	rp												0.947**	0.306**	0.901**	-0.325**	-0.182
Pol % (10M)	**rg**													0.674**	0.996**	-0.398**	-0.305**
	rp													0.595**	0.993**	-0.280*	-0.268*
Purity % (10M)	**rg**														0.735**	-0.111	-0.514**
	rp														0.687**	-0.022	-0.345**
CCS % (10M)	**rg**															-0.376**	-0.340**
	rp															-0.255*	-0.292**
Extraction %	**rg**																0.079
	rp																0.063

*Significant at 5% level and ** Significant at 1% level

Table 4. Direct (diagonal values) and indirect effects of different characters on cane yield at phenotypic level

	No. of Tillers at 120 days	No. of Shoots at 240 days	No. of Millable canes at Harvest	Single cane wt.(Kg)	Cane length(cm)	Cane Girth (cm)	CCS (t/ha.)	Brix % (8M)	Pol % (8M)	Purity% (8M)	CCS % (8M)	Brix % (10M)	Pol % (10M)	Purity % (10M)	CCS % (10M)	Extraction %	Correlation with Yield
No. of Tillers at 120 days	**0.0019**	-0.0120	0.0267	0.0126	-0.0005	0.0005	0.3965	-0.0139	-0.0300	-0.0015	0.0477	0.0305	0.0270	0.0606	-0.1031	0.0001	**0.443**
No. of Shoots at 240 days	0.0013	**-0.0173**	0.0316	0.0092	-0.0003	0.0012	0.4317	-0.0656	0.2150	0.0001	-0.1487	-0.0524	-0.0162	0.0200	0.0404	0.0002	**0.450**
No. of Millable canes at	0.0012	-0.0133	**0.0410**	0.0154	-0.0005	-0.0006	0.5781	-0.0181	0.0566	0.0001	-0.0386	0.1101	0.0622	0.0856	-0.2122	0.0000	**0.667**

Harvest																	
Single cane Weight (kg)	0.0004	-0.0030	0.0117	**0.0539**	-0.0005	-0.0048	0.7266	-0.0684	0.1416	-0.0021	-0.0698	0.1465	0.1119	0.2455	-0.4087	-0.0003	**0.881**
Cane length(cm)	0.0009	-0.0047	0.0164	0.0213	**-0.0012**	-0.0015	0.3602	0.0321	-0.1783	-0.0014	0.1491	0.1609	0.0681	0.0257	-0.2089	-0.0012	**0.437**
Cane Girth (cm)	-0.0001	0.0022	0.0027	0.0287	-0.0002	**-0.0090**	0.2357	0.1269	-0.5280	-0.0021	0.4058	0.5415	0.2641	0.2385	-0.8550	-0.0001	**0.452**
CCS (t/ha.)	0.0008	-0.0084	0.0266	0.0440	-0.0005	-0.0024	**0.8908**	-0.1617	0.5553	0.0002	-0.3948	-0.1753	-0.0552	0.0615	0.1438	0.0001	**0.925**
Brix % (8M)	0.0001	-0.0026	0.0017	0.0084	0.0001	0.0026	0.3271	**-0.4403**	1.6732	0.0041	-1.2420	-0.8175	-0.3216	-0.0103	0.9532	0.0007	**0.137**
Pol % (8M)	0.0000	-0.0021	0.0013	0.0044	0.0001	0.0027	0.2835	-0.4223	**1.7448**	0.0070	-1.3375	-0.8423	-0.3498	-0.0899	1.0631	0.0008	**0.064**
Purity% (8M)	-0.0002	-0.0001	0.0002	-0.0097	0.0001	0.0016	0.0144	-0.1515	1.0333	**0.0119**	-0.9052	-0.4864	-0.2561	-0.2847	0.8511	0.0008	**-0.180**
CCS % (8M)	-0.0001	-0.0019	0.0012	0.0028	0.0001	0.0027	0.2614	-0.4066	1.7349	0.0080	**-1.3451**	-0.8342	-0.3531	-0.1177	1.0823	0.0008	**0.035**
Brix % (10M)	-0.0001	-0.0008	-0.0042	-0.0073	0.0002	0.0045	0.1437	-0.3312	1.3520	0.0053	-1.0324	**-1.0869**	-0.4755	-0.2272	1.4764	0.0013	**-0.182**
Pol % (10M)	-0.0001	-0.0006	-0.0051	-0.0120	0.0002	0.0047	0.0979	-0.2820	1.2154	0.0061	-0.9460	-1.0292	**-0.5021**	-0.4423	1.6263	0.0011	**-0.268**
Purity % (10M)	-0.0002	0.0005	-0.0047	-0.0178	0.0000	0.0029	-0.0737	-0.0061	0.2109	0.0046	-0.2130	-0.3322	-0.2988	**-0.7432**	1.1258	0.0001	**-0.345**
CCS % (10M)	-0.0001	-0.0004	-0.0053	-0.0134	0.0002	0.0047	0.0782	-0.2562	1.1323	0.0062	-0.8886	-0.9796	-0.4985	-0.5108	**1.6382**	0.0010	**-0.292**
Extraction %	0.0000	0.0011	0.0000	0.0046	-0.0004	-0.0003	-0.0334	0.0755	-0.3624	-0.0026	0.2918	0.3536	0.1407	0.0164	-0.4175	**-0.0038**	**0.063**

Residual effect = 0.00193

REFERENCES

Ahmed, K. I., Patil, S. B., Hanamaratti, N. G., Nadgouda, B. T. and Moger, N. B. (2019). Genetic variability studies for yield and its component traits in selected clones of sugarcane. *Journal of Pharmacognosy and Phytochemistry*, 8(2): 894-898.

Al-Jibouri, H. A., Miller, A. R. and Robinson, H. F. (1958).Genotypic and environmental variances and co-variances in upland cotton crosses of interspecific origin. *Agronomy Journal*, 50: 633-637.

Anonymous (2020). Cooperative sugar 51(5), 2020

Burton, G. W. (1952). Quantitative inheritance of grasses. Proc 6th Int, Grassland Congress 1, 277-283.

Burton, G. W. and Devane, E. H. (1953). Estimating heritability in tall Fescue (*Festucaarundinacea*) from replicated clonal material. *Agronomy Journal*, 45: 478-481.

Dewey, D. R. and Lu, K. H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal*, 51: 515-518.

Fisher, R.A. and Yates, F.(1967). Statistical Tables for Biological, Agricultural and Medical Research, sixth ed. Olivier and Boyd, London (reprinted).

Gowda, S. N. S., Saravanan, K. and Ravishankar, C. R. (2016).Genetic variability, heritability and genetic advance in selected clones of sugarcane. *Plant Archives*, 16(2): 700-704.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. (1955).Estimates of genetic and environmental variability of Soybeans. *Agronomy Journal*, 47: 314-318.

Kumari, P., Kumar, B., Kamat, D. N., Singh, R., Singh, D. and Chhaya, R. (2020). To study genetic variability, heritability and genetic advance for cane and sugar yield attributing traits in mid-late maturing sugarcane clones. *Journal of Pharmacognosy and Phytochemistry*, 9(1): 1890-1894.

Panse, V.G. and Sukhatme, P. V. (1967).Statistical methods for agricultural workers. 2nd edition: Indian Council of Agricultural Research, New Delhi, pp: 381.

Parihar, R. (2020). Character association and path coefficient analysis for cane yield and quality characters in fourth clonal generation (C4) of sugarcane (Saccharum sp. complex). *Journal of Crop and Weed*, 16(1): 256-260.

Sanghera, G. S., Kashyap, L., Anuradha, Kumar, R., Bhatt, R. and Singh, H. (2018). Genetic variability studies in sugarcane (Saccharum sp. hybrid complex) under water stress and non-stress conditions. *International Journal of Genetics*, 10(5): 425-433.

Tyagi, S. D. and Singh, D. N. (1998). Studies on genetic variability for stalk characters in sugarcane. *Indian Sugar*, 48: 259-262.

Viradiya, Y. A., Damor, P. R., Joshi, H. K., Koladiya, P. B. and Gadhiya, A. A. (2016). Correlation and path coefficient analysis in sugarcane. *The Bioscan*, 11(2):1007-1010.