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Genetic variability studies for yield and its component traits in selected clones of sugarcane

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Abstract
The present investigation was undertaken to estimate the genetic parameters on 18 quantitative traits of 38 clones selected from clonal-I ratoon population derived from a cross Co 7204 x Co Pant 97222 and 7 commercial sugarcane genotypes. Analysis of variance revealed significant differences among the clones for all the characters studied, indicating the presence of considerable amount of variability in the genetic material. The clones SNK 13101, SNK13044, SNK13219, SNK13142, SNK 13049 SNK 13135 and SNK 13158 recorded significantly superior cane and sugar yield over best standard SNK 632 and both the parents. Hence, above clones can be advance to large scale yield trails and also utilized in the hybridization programmes to bring yield improvement in sugarcane. The high estimates of GCV, PCV, heritability (broad sense) and genetic advance as percent of mean were recorded for green top weight, green top yield, commercial cane sugar yield, brix yield and cane yield indicating that simple selection would be helpful for the improvement of these traits as these are governed by additive gene action whereas plant height, sucrose percent and commercial cane sugar percent recoded moderate heritability along with genetic advance suggesting that characters are governed by both additive and non-additive gene action.

Keywords: Genetic advance, heritability, variability, GCV, PCV, sugarcane

Introduction
Sugarcane (*Saccharum spp.* 2*n* =60–170) growing countries of the world lay between the latitude 36.7° north and 31.0° south of the equator extending from tropical to subtropical zones. It is the world's largest crop by production quantity. In 2017, The Food and Agriculture Organization (FAO) estimate it was cultivated on about 25.97 million hectares, in more than 90 countries, with a worldwide harvest of 1.84 billion tons. Brazil was the largest producer of sugarcane in the world with the production of 758548 thousand metric tons (TMT) with an area of 10184 thousand hectares and with the productivity of 74.48 tonnes per hectare followed by India, China, Thailand, Pakistan and Mexico respectively (http://www.fao.org/faostat; 2017). At present in India sugarcane occupies an area of 4668.7 thousand hectares with annual production of 337694.5 thousand tonnes and with a productivity of 72.34 tonnes per hectare. In India, major sugarcane producing states are Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu and Bihar. In Karnataka, it occupies an area of 400 thousand hectares with the production of 30400 thousand tonnes and with the productivity of 76 tonnes per hectare (https://www.indiaagristat.com; 2017-18).
To meet the expected combined demand posed by anticipated population and consumption increase along with the other challenges, India will have to produce 51 million tonnes of white sugar by 2050 from the present 27.7 million tonnes, which will be possible only with a quantum jump in sugarcane productivity and sugar recovery (Chogatapur *et al.*, 2017) [4]. In context of this, there is huge demand for the development of sugarcane varieties with high tonnage and sucrose percent which is in turn one of the initial goals of the variety development program. Hence understanding the various genetic parameters is a basic step for improvement of any crop. Estimation of genetic variability in conjunction with heritability and genetic advance gives an idea of the possible improvement of the character through selection. Keeping these in view, the present study was taken up to assess genetic parameters for quantitative traits in pre-selected hybrid sugarcane clones of promising cross involving tropical Co 7204 and subtropical Co Pant 97222 parents.

Materials and methods
The research was conducted at Agricultural Research Station, Sankeshwer during 2017-18. The experimental material for the present investigation consisted of 38 clones selected form

clonal-I ratoon population derived from a cross Co 7204 x Co Pant 97222 and 7 commercial sugarcane genotypes. The experiment was laid out in RBD with two replications and all the recommended package of practices for cultivation of sugarcane crop was followed. The cane samples were drawn at random from each replication and data were recorded for characters *viz.*, number of millable canes at 300 (DAP) days after planting (NMC), Single cane weight (SCW), Green top weight (GTW), Cane height (CH), Plant height (PH), Girth of cane (GTH), Number of Internodes (INT), Internodal length (INL), Harvest Index (HI), Juice extraction percent (JE), Green top yield (GTY), Brix percent (CB) at 12th month, Sucrose percent (%) (CP) at 12th month, Purity percent (PT), Commercial cane sugar percent, Commercial cane sugar yield (CCSY), Brix yield (BY) and Cane yield (CY).

Statistical Analysis: The analysis of variance (ANOVA) was worked out according to the procedure of Randomized Block Design for each character as per methodology advocated by Panse and Sukhatme (1967) [9]. The analysis of variance was used to derive variance components (Cochran and Cox, 1957) [5].

Estimation of the genotypic and phenotypic coefficient of variation: The formulae used to calculate PCV and GCV were given by Burton and De vane (1953) [3].

Heritability (Broad Sense): Heritability in broad sense was estimated by the formula given by Johnson *et al*. (1955) [7]. The heritability was categorized as low, moderate and high as given by Robinson *et al*. (1949) [12].

Genetic Advance: The estimates of genetic advance were obtained by the formula given by Lush (1949) [8], Johnson *et al.* (1955) [7] and Allard (1960) [2]. The range of genetic advance is classified as suggested by Johonson *et al.* (1955) [7].

Results and discussion

Analysis of variance revealed significant differences among the clones for all the characters studied, indicating the presence of a considerable amount of variability in the materials (Table 1 & 2). The clone SNK 13101, recorded significantly high mean performance for cane yield and sugar yield followed by SNK13044, SNK13219, SNK13142, SNK 13049 SNK 13135 and SNK 13158 respectively over best standard SNK 632 and best parent. The SNK 13049 clone also showed high mean performance for commercial cane sugar yield, commercial cane sugar percent, single cane weight, girth of cane, harvest Index, sucrose percent, purity percent, brix yield and brix percent. The clones SNK 13101, SNK13044, SNK13219, SNK13142, SNK 13049 SNK 13135 and SNK 13158 also showed moderate to high mean performance for most of the other traits studied. Hence, these promising hybrid clones can be advanced to extensive yield trial for possible identification of commercial clones or as a parent material further breeding program.

Wide range of variation among hybrid clones was recorded for almost all the commercially important traits especially number of millable canes, single cane weight, sucrose percent, harvest index and green top yield. In the present study, the estimates of the phenotypic coefficient of variation (PCV) for all the characters were higher than the estimates of the genotypic coefficient of variation (GCV), which may be due to the interaction of genotypes with the environment (Table 3). The highest estimates of phenotypic coefficients of variation and genotypic coefficient of variation were registered for Green top yield, green top weight, commercial cane sugar yield, cane yield and brix yield respectively. All traits exhibited a relatively low magnitude of the difference between PCV and GCV indicating a less environmental influence on these characters (Patil *et al.*, 2014) [10]. These results are in accordance with the findings of Swamy Gowda *et al.* (2016) [14] and Guddadamath (2013) [6] for commercial cane sugar yield and cane yield.

Moderate estimates of the genotypic coefficient of variation and higher estimates of the phenotypic coefficient of variation were recorded for single cane weight. Similarly, moderate estimates of GCV & PCV were recorded for number of millable canes followed by cane height, plant height, and number of internodes. These results are in agreement with the findings of Relisha Ranjan *et al.* (2017) [11] for Plant height; Guddadamath (2013) [6] for cane height and number of internodes.

Heritability measures the relative amount of heritable portion of variability. It is a good index of the transmission of characters from parents to offspring. The perusal of Table 3 revealed the estimates of heritability in broad sense for eighteen characters studied, which ranged from 16.1 to 89.8 percent. High heritability was recorded for cane yield, brix yield, single cane weight, commercial cane sugar yield, plant height, brix percent, sucrose percent, green top yield, number of millable canes, green top weight, commercial cane sugar percent and harvest index respectively. This indicates that the least influence of environment on the expression of these characters. Therefore, for improving these traits through simple selection will be more effective on the basis of *per se* performance. These results are in correspondence with the findings of Swamy Gowda *et al.* (2016) [14] for cane yield, brix yield, commercial cane sugar yield, brix percent, sucrose percent, number of millable canes and commercial cane sugar percent, Relisha Ranjan *et al.* (2017) [11] for commercial cane sugar percent, cane yield, sucrose percent, brix percent, plant height and single cane weight and Guddadamath (2013) [6] for cane yield, commercial cane sugar yield, brix percent and number of millable canes.

Heritability estimates along with genetic advance are more useful than heritability alone in predicting the effectiveness of selection. Further, the heritability estimates coupled with expected genetic advance as percent of mean indicates the mode of gene action in choosing an appropriate breeding methodology. High heritability coupled with high genetic advance as percent of mean recorded for cane yield, brix yield, single cane weight, commercial cane sugar yield, green top yield, number of millable canes, green top weight and harvest index, indicate that additive gene action is involved in the genetic control of these traits. Hence, simple selection may help in improving these traits. These results are in correspondence with the findings of Swamy Gowda *et al.* (2016) [14] for commercial cane sugar yield, cane yield, number of millable canes, cane yield, brix yield, single cane weight and number of millable canes, Relisha Ranjan *et al.* (2017) [11] for Cane yield, single cane weight and commercial cane sugar yield and Alam *et al.* (2017) [1] for single cane weight and number of millable canes.

High heritability coupled with moderate genetic advance as percent of mean recorded for plant height, pole percent and commercial cane sugar percent suggests that the trait is controlled by both additive and non-additive gene action.

Similar kind of results was noted for plant height and sucrose percent by Relisha Ranjan *et al.* (2017) [11].

From the above discussion it can be concluded that, high estimates of GCV, PCV, heritability (broad sense) and genetic advance as percent of mean were recorded for green top weight, green top yield, commercial cane sugar yield, brix yield and cane yield indicating that simple selection would be helpful for the improvement of these traits as these are governed by additive gene action whereas plant height, sucrose percent and commercial cane sugar percent moderate heritability and genetic advance suggesting that characters are governed by both additive and non additive gene action. Similarly the promising clones *viz.*, SNK 13101, SNK13044, SNK13219, SNK13142, SNK 13049 SNK 13135 and SNK 13158 could be advanced for further extensive yield trails for possible identification of commercial clones or parent material in future.

Table 1: Analysis of variance for eighteen characters in 47 sugarcane clones

S. No.	Characters (s)	Mean sum of squares		
		Replications (df: 1)	Genotypes (df:46)	Error (df:46)
1.	Numer of Millable Canes (per plot)	0.17	159.336**	29.648
2.	Single cane weight (kg)	0.011	0.124**	0.007
3.	Green top Weight (kg)	0.00001	0.008**	0.001
4.	Cane Height (m)	0.777	0.167**	0.043
5.	Plant height (m)	0.035	0.315**	0.034
6.	Girth of cane (cm)	0.039	0.1007**	0.027
7.	Number of Internode	111.311	10.649**	4.074
8.	Internodal length (cm)	7.504	5.018*	2.552
9.	Harvest Index (%)	0.305	25.774**	5.772
10.	Juice Extraction (%)	600.42	101.592	73.467
11.	Green top yield (t/ha)	0.801	50.317**	8.569
12.	Brix percent (%)	2.298	2.064**	0.274
13.	Sucrose percent (%)	2.008	4.225**	0.711
14.	Purity percent (%)	142.877	25.88**	11.802
15.	Commercial cane sugar percent (%)	3.796	3.278**	0.718
16.	Commercial cane sugar yield (t/ha)	0.288	15.664**	1.285
17.	Brix yield (t/ha)	6.771	33.721**	1.846
18.	Cane Yield (t/ha)	43.302	684.066**	36.943

* Significant at 5% level; ** Significant at 1 % level

Table 2: Mean performance of forty seven sugarcane clones for eighteen characters.

S.N	Name	NMC	SCW	GTW	CH	PH	GTH	INT	INL	HI	JE	GTY	CB	CP	PTY	CCS%	CCS Yield	BY	CY
1	Co 94012	46.50	1.25	0.31	1.94	3.21	2.74	17.50	11.09	80.28	45.93	17.57	24.87	23.97	96.41	17.71	12.67	17.80	71.55
2	Co 92005	24.50	1.11	0.18	1.52	2.62	2.64	16.34	9.32	86.36	49.14	5.29	22.87	21.69	94.86	15.92	5.33	7.66	33.47
3	SNK 044	45.00	1.22	0.17	1.94	2.89	2.51	17.17	11.77	88.20	48.93	9.06	22.11	20.68	93.53	15.09	10.22	14.98	67.73
4	Co 86032	59.50	1.08	0.17	1.87	3.16	2.42	16.17	12.18	86.74	38.44	12.12	22.61	21.00	92.88	15.27	12.14	17.96	79.53
5	SNK 632	38.50	1.74	0.22	2.32	3.90	3.05	22.00	10.53	88.77	58.38	10.43	22.61	21.11	93.34	15.38	12.67	18.63	82.37
6	CoM 0265	41.50	1.52	0.25	2.32	3.87	2.78	19.50	11.92	85.98	61.38	12.51	21.63	20.12	93.04	14.64	11.17	16.49	76.26
7	Co 2001-15	46.50	1.14	0.20	2.21	3.38	2.46	16.00	14.09	85.00	45.06	11.56	22.12	20.87	94.39	15.28	9.99	14.45	65.38
8	Co 7204	34.50	1.16	0.21	2.29	3.32	2.52	18.83	12.12	84.99	49.34	8.63	22.87	21.21	92.80	15.41	7.52	11.17	48.83
9	Co Pant 97222	54.50	0.90	0.14	1.84	3.13	2.54	16.00	11.55	87.07	51.43	8.86	24.12	23.86	98.93	17.82	10.71	14.49	60.09
10	SNK 13012	59.50	1.40	0.21	2.37	3.98	2.54	19.17	12.54	86.89	47.02	15.38	22.87	20.33	88.99	14.49	14.81	23.34	102.19
11	SNK 13013	49.50	1.15	0.11	1.96	3.02	2.61	16.83	11.67	91.10	43.31	6.76	21.62	19.25	89.04	13.73	9.62	15.14	70.19
12	SNK 13033	58.50	1.27	0.33	2.30	3.33	2.58	16.00	14.57	79.20	55.65	23.80	23.12	21.43	92.70	15.56	14.14	20.95	90.64
13	SNK 13035	49.00	1.33	0.15	2.16	3.32	3.01	17.67	12.24	89.97	51.11	8.93	24.12	23.50	97.44	17.44	14.01	19.37	80.49
14	SNK 13044	51.00	1.81	0.31	2.51	4.03	3.00	22.17	11.35	85.12	63.51	20.02	21.61	19.74	91.31	14.25	16.10	24.41	112.93
15	SNK 13148	42.00	0.81	0.10	2.07	3.07	2.27	17.50	11.80	89.47	51.22	4.99	22.13	19.70	89.15	14.05	5.85	9.25	41.75
16	SNK 13049	46.00	1.86	0.16	2.45	3.63	3.07	19.00	12.90	92.35	46.74	8.71	24.12	23.86	98.93	17.82	18.81	25.49	105.67
17	SNK 1350	41.00	1.49	0.26	2.49	4.21	2.78	18.50	13.45	85.03	63.44	13.94	23.37	21.05	90.12	15.10	11.30	17.52	74.91
18	SNK 13053	53.50	1.16	0.31	2.59	4.35	2.34	15.34	17.20	79.06	45.55	20.35	22.87	20.97	91.73	15.16	11.58	17.44	76.32
19	SNK 13054	44.00	1.38	0.24	2.60	2.89	2.59	18.17	14.41	85.19	52.29	13.08	23.37	21.05	90.10	15.09	11.21	17.34	74.28
20	SNK 13067	56.50	1.37	0.17	2.50	3.60	2.71	19.84	12.62	89.09	57.46	11.64	22.62	20.14	89.05	14.36	13.65	21.55	95.25
21	SNK 13071	51.50	1.14	0.22	2.26	3.99	2.33	19.67	11.47	83.73	44.72	13.91	24.87	23.97	96.42	17.71	12.67	17.81	71.57
22	SNK 1376	57.00	1.18	0.15	2.11	3.60	2.43	16.84	12.53	89.13	46.14	10.14	22.62	20.64	91.25	14.89	12.27	18.66	82.49
23	SNK 13095	53.00	1.56	0.34	2.51	3.93	2.69	20.50	12.22	82.10	55.97	22.26	21.12	18.33	86.77	12.91	13.15	21.51	101.82
24	SNK 13096	51.50	1.14	0.16	2.30	3.83	2.69	20.50	11.22	87.72	58.06	10.10	23.37	20.84	89.19	14.87	10.76	16.92	72.35
25	SNK 13101	54.50	1.78	0.20	2.87	3.68	2.89	20.17	14.25	90.18	51.69	12.95	21.37	18.43	86.25	12.94	15.46	25.54	119.41
26	SNK 13109	43.00	1.49	0.19	2.22	3.68	2.51	23.50	9.46	88.76	44.74	10.05	21.12	18.21	86.20	12.78	10.09	16.67	78.85
27	SNK 13120	45.00	1.47	0.21	2.24	3.63	2.77	16.50	13.53	87.55	59.17	11.48	21.86	20.64	94.44	15.11	12.25	17.76	81.05
28	SNK 13123	58.00	0.89	0.14	1.86	3.39	2.62	15.17	12.47	86.72	60.84	9.77	22.37	19.50	87.28	13.77	8.79	14.23	63.64
29	SNK 13125	62.00	1.11	0.28	1.57	3.59	2.78	14.83	10.62	79.62	56.22	21.53	22.38	22.50	100.43	16.91	14.26	18.85	84.13
30	SNK 13134	49.00	1.55	0.34	2.11	3.64	3.18	15.00	14.20	82.26	67.90	20.01	20.87	19.51	93.43	14.22	13.10	19.23	92.34
31	SNK 13135	63.00	1.36	0.22	2.26	3.92	2.61	19.00	11.90	86.28	50.50	16.75	23.62	22.12	93.66	16.14	16.93	24.81	105.04
32	SNK 13142	58.50	1.47	0.19	2.67	3.79	2.77	22.67	12.00	88.88	50.05	13.20	22.58	21.00	93.01	15.28	16.15	23.89	105.78

33	SNK 13144	45.00	1.03	0.13	2.25	3.26	2.34	14.67	15.33	89.00	43.46	6.89	21.62	20.32	93.99	14.85	8.46	12.32	56.96
34	SNK 13145	43.50	1.36	0.11	2.75	3.92	2.44	21.00	13.08	92.70	43.61	5.83	23.12	21.19	91.67	15.32	11.15	16.82	72.73
35	SNK 13153	49.00	1.09	0.19	2.28	3.83	2.42	17.84	12.76	85.40	46.20	11.25	24.37	23.86	97.91	17.74	11.70	16.07	65.93
36	SNK 13158	58.00	1.42	0.13	2.43	3.50	2.83	17.00	14.26	91.90	48.61	8.94	23.12	21.05	91.07	15.17	15.39	23.46	101.46
37	SNK 13178	72.00	1.01	0.23	2.30	3.24	2.66	20.50	11.45	81.27	60.02	20.71	23.62	23.26	98.50	17.34	15.55	21.19	89.71
38	SNK 13187	55.50	1.00	0.11	2.14	3.21	2.30	18.17	11.79	90.35	45.33	7.49	24.37	21.20	87.18	14.95	10.07	16.65	68.26
39	SNK 13188	45.00	1.43	0.21	2.19	3.35	2.56	18.84	11.72	87.44	47.94	11.33	22.87	20.98	91.77	15.17	11.98	18.09	79.07
40	SNK 13201	68.50	1.12	0.27	2.11	4.28	2.53	20.67	10.15	80.77	44.15	22.52	21.62	20.32	93.99	14.85	14.06	20.48	94.71
41	SNK 13205	57.00	1.31	0.23	2.11	3.01	2.43	14.50	14.49	85.01	42.14	16.10	21.58	19.59	90.76	14.09	12.92	19.77	91.54
42	SNK 13207	55.50	1.02	0.25	1.83	3.13	2.49	16.00	11.30	80.73	42.45	16.63	22.37	20.42	91.33	14.74	10.27	15.58	69.66
43	SNK 13209	51.50	1.23	0.26	1.85	3.92	2.45	14.17	12.91	82.46	37.25	16.61	21.62	20.32	93.99	14.85	11.52	16.78	77.59
44	SNK 13217	54.00	0.92	0.12	1.93	3.95	2.19	17.67	10.80	88.42	41.62	8.23	22.83	20.88	91.51	15.08	9.16	13.83	60.82
45	SNK 13219	53.50	1.64	0.27	2.63	3.64	2.85	17.67	15.00	85.93	45.99	17.77	21.83	20.54	94.12	15.02	16.24	23.58	108.08
46	SNK-13220	67.50	1.21	0.14	2.27	3.60	2.50	16.00	14.52	89.59	45.09	11.76	23.83	20.26	85.20	14.12	14.19	23.84	100.18
47	SNK 13348	58.00	1.31	0.24	2.34	3.88	2.59	18.84	12.42	84.68	44.71	16.79	22.09	20.56	93.13	14.97	13.89	20.49	92.83
	Mean	51.51	1.28	0.20	2.22	3.56	2.61	18.03	12.49	86.26	50.00	13.07	22.69	20.98	92.41	15.22	12.25	18.30	80.80
	CV	10.57	6.91	20.19	9.39	5.24	6.30	11.19	12.79	2.79	17.14	22.39	2.31	4.02	3.72	5.57	9.26	7.43	7.52
	S.E.	3.85	0.06	0.03	0.15	0.13	0.12	1.43	1.13	1.70	6.06	2.07	0.37	0.60	2.43	0.60	0.80	0.96	4.30
	C.D.5%	10.96	0.18	0.08	0.42	0.38	0.33	4.06	3.22	4.84	-	5.89	1.05	1.70	6.92	1.71	2.28	2.74	12.23

Table 3: Mean, the coefficient of variability, heritability (broad sense) and genetic advance as percent of the mean for 18 characters in sugarcane.

S. No.	Character (s)	Mean	Range		Variance		Coefficient of Variation		Heritability (Broad sense) (%)	Genetic advance (GA)	Genetic advance as percent of the mean (%)
			Min.	Max.	Genotypic	Phenotypic	Genotypic	Phenotypic			
1	Numer of Millable Canes (per plot)	51.51	24.50	72.00	64.84	94.49	15.63	18.87	68.60	13.74	26.68
2	Single cane weight (kg)	1.28	0.81	1.86	0.06	0.07	18.85	20.07	88.10	0.47	36.45
3	Green top Weight (kg)	0.21	0.10	0.34	0.00	0.01	28.92	35.27	67.20	0.10	48.84
4	Cane Height (m)	2.22	1.52	2.87	0.06	0.11	11.17	14.59	58.60	0.39	17.63
5	Plant height (m)	3.56	2.62	4.35	0.14	0.18	10.53	11.77	80.20	0.69	19.43
6	Girth of cane (cm)	2.62	2.19	3.18	0.04	0.06	7.34	9.67	57.50	0.30	11.46
7	Number of Internode	18.03	14.17	23.50	3.29	7.36	10.06	15.05	44.70	2.50	13.84
8	Internodal length (cm)	12.49	9.32	17.20	1.23	3.79	8.89	15.58	32.60	1.31	10.45
9	Harvest Index (%)	86.26	79.06	92.70	10.00	15.77	3.67	4.60	63.40	5.19	6.01
10	Juice Extraction (%)	50.00	37.25	67.90	14.06	87.53	7.50	18.71	16.10	3.10	6.19
11	Green top yield (t/ha)	13.08	4.99	23.80	20.87	29.44	34.94	41.50	70.90	7.93	60.61
12	Brix percent (%)	22.69	20.87	24.87	0.90	1.17	4.17	4.77	76.60	1.71	7.52
13	Sucrose percent (%)	20.98	18.21	23.97	1.76	2.47	6.32	7.49	71.20	2.30	10.98
14	Purity percent (%)	92.41	85.20	100.43	7.04	18.84	2.87	4.70	37.40	3.34	3.62
15	Commercial cane sugar percent (%)	15.22	12.78	17.82	1.28	2.00	7.43	9.29	64.00	1.87	12.26
16	Commercial cane sugar yield (t/ha)	12.25	5.33	18.81	7.19	8.48	21.89	23.76	84.80	5.09	41.52
17	Brix yield (t/ha)	18.30	7.66	25.54	15.94	17.78	21.82	23.05	89.60	7.79	42.54
18	Cane Yield (t/ha)	80.80	33.47	119.41	323.56	360.51	22.26	23.50	89.80	35.11	43.45

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