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To study genetic variability, heritability and genetic advance for cane and sugar yield attributing traits in mid-late maturing sugarcane clones

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Abstract
Thirteen mid late maturing sugarcane clones including two checks were planted in randomized block design with three replications during 2018-19 at Research Farm, RPCAU, Pusa, Samastipur, Bihar to study the genetic variability, heritability and genetic advance for cane and sugar yield along with its component traits. Highly significant differences for all the characters were observed among the 13 clones under studied. Higher numerical values of phenotypic variances and co-variances with respect to its genotypic counterpart were recorded for all the traits indicating greater environmental influence on these traits for total variation. High heritability coupled with high genetic advance as percent of means were observed for sugar yield, cane yield, germination % at 45 days, cane height, single cane weight at harvest and fiber % at harvest, it indicates the presence of additive gene action therefore, clonal selection based on above said traits might be effective method for sugarcane improvement programme. These traits can be considered for further clonal selection and genetic improvement of mid late maturing sugarcane clones.

Keywords: Sugarcane, mid-late maturity, genetic variability, heritability and genetic advance percentage of mean

Introduction
Sugarcane is the second most important industrial crop in the India, here sustaining millions of sugarcane farmers and livelihoods on sugarcane production. Sugarcane was cultivated in 4.7 million hectares of area with total production of 355.09 million tonnes with productivity of 74.4 tonnes/ha in India whereas, Bihar has an area of 0.243 million hectare with production of 16.5 million tonnes and productivity 67.9 t/ha (Issued by Department of Agriculture & Farmers Welfare, 2017-2018). Improvement for sugar yield as well as productivity of sugarcane needs to further genetic study of variability which is prerequisite. Variability is measure by estimation of genotypic and phenotypic variance (σ^2g and σ^2p), genotypic and phenotypic coefficient of variation (GCV and PCV), heritability (h^2), genetic advance (GA) and genetic advance as per cent of mean (GM). It is well known fact that environment plays an important role in the expression of phenotype. The phenotypic variability which is observable includes both genotypic (heritable) and environmental variation (non-heritable). Hence, variability can be estimated through analysis of variance and statistical calculations. If any traits have high heritability couple with moderate to high genetic advance as per cent of mean, that indicates trait/traits will be considered for effective selection in sugarcane breeding programme. Availability of wide range of genetic variability in the sugarcane is the basic requirement to select better clones bearing high sugar and cane yield. Therefore, study of above said genetic parameters will help in further sugarcane improvement programme.

Materials and Methods
Thirteen sugarcane clones including two checks were planted in Randomized Block Design with three replications during 2018-19 at RPCAU, Pusa, Bihar. The materials includes 11 entries of promising mid late maturing sugarcane clones *namely*, CoP 15438, CoP 15439, CoP 15440, CoP 15441, CoSe15453, CoSe 15454, CoSe 15457, CoLk 15468, CoLk 15469, CoBln 15502,CoP 2061 and two checks viz., BO 91and CoP9301. The plot size was 6 rows of 6 meters length each and spacing of 0.90 meter between rows. 150 three budded sets in every plot each genotype was separately planted in all three replications follow all recommended package and practices to raise good crop. Data observations were recorded for 20 traits *viz.*,

germination percentage at 45 days, number of shoots at 120 DAP (000/ha), number of tillers at 240 days (000/ha), plant height at harvest (cm), cane diameter at harvest (cm), fiber % at harvest, extraction % at harvest, single cane weight (Kg), number of millable cane (000/ha) at harvest, brix % at 10 month stage, pol % in juice at 10 months stage, purity % at 10 months stage, CCS % at 10 month stage, brix % at 12 month stage, pol % in juice at 12 months stage, purity % at 12 months stage, CCS %at 12 month stage, pol % in cane, cane yield (t/ha) and CCS t/ha (sugar yield) at harvest for observation. Randomly 5 clones from each plot were used and calculate its average measure for plant height at harvest (cm), cane diameter at harvest (cm), single cane weight (Kg) while for number of shoots at 120 DAP, number of tillers at 240 days, number of millable cane at harvest by counting the number of cane per plot of each genotype and its average was calculated after that converted in thousand per hectare. Germination % was also calculated after counting the germinated plants per lot from total number of bud planted in each plot (total 150 three budded sets it menace 150 x 3= 600 buds). Cane yield was calculated per lot basis quintals/plot and converted into tonnes per hectare. 250 g sample from each plot collected and by using rapid pol extraction device flowed by dryer oven, weight of dry fiber measure and finally fiber percentage was estimated. For juice quality data randomly 5 samples were collected per plot and after crushing of cane extracted juice of each sample subjected to analysis for Bix, and pol percent in juice using brix hygrometer and polari scope. All the observed data of twenty traits were statistically analyzed in order to assess and quantify the genetic variability among the genotypes. For estimation of variance components viz., phenotypic variances ($\sigma^2 p$) and genotypic variances ($\sigma^2 g$) both were estimated using the following formula as suggested by Panse and Sukhatme (1967).

Genotypic Variance = (vMSS – eMSS) x CF
Phenotypic Variance = $\sigma^2 g$ + EMS
Both genotypic and phenotypic coefficient of variability were computed for each character as per method suggested by Burton and De Vane (1953)
Genotypic Coefficient of Variation (GCV) = Genotypic standard deviation divided by grand mean of the character × 100
Phenotypic Coefficient of Variation (PCV) = Phenotypic standard deviation divided by grand mean of the character × 100
Heritability (h^2) It was estimated in broad sense by using following formula as suggested by Lush (1940). h^2 = Genotypic variances ($\sigma^2 g$) divided by Phenotypic variances ($\sigma^2 p$) × 100
The heritability was categorized as low (0-30%), moderate (30-60%) and high (60 and above) as given by Robinson *et al*., (1949).

Genetic advance as per cent of mean (GAM)
GAM (%) = Genetic advance (GA) divided by General mean of population (Gm) × 100
Genetic advance as per cent mean was categorized as low (0-10%), moderate (10-20%) and high (20 and above) as given by Johnson *et al*. (1955).

Results and Discussion
Variability among the mid late maturing sugarcane clones is the present need of sugarcane improvement programme. In Bihar more than 60% of sugarcane cultivated area under the state coved by midlate maturity group while productivity was found less than national average and reflected low sugar yield. The analysis of variance as per overview given in Table no.-1, clearly indicated that highly significant differences were found among the clones for all the traits under studied it clearly indicated that there were sufficient variability existed in the mid maturing sugarcane clones for sugar yield and its component traits. Similar results were also reported by earlier workers Hiremath and Nagaraja (2016) [12], Ijaz *et al.* (2013) [13], Kheni *et al.* (2015) [16, 21], Agrawal and Kumar (2017), Bairwa *et al*. (2017) [6], Krishna *et al.* (2017) [17], Kumar *et al*. (2018) and Anbanandan & Eswaran (2018) [5]. Phenotypic and genotypic variance were computed for all the twenty cane and sugar yield along with its component traits under study given in Table no. -2. The numerical value of phenotypic variance was higher than their genotypic counterpart for all the characters. This is due to the reasons that some non-genetic factors have played an important role in the manufacture of these traits. Highest value for genotypic and phenotypic variances were observed by the traits *viz*. cane height at harvest followed by cane yield, number of milliable cane at harvest, number of tillers at 240 days and number of shoots at120 DAP. Similar finding was also reported by Gowda *et al.* (2016) [11] for number of tillers, Bora *et al*. (2014) [7] for number of milliable cane, cane height and shoots number, Puneet *et al*. (2002) [2] agree with higher genetic variation in stalk height while not agree for stalk diameter. In present study, phenotypic coefficient of variation (PCV) was observed higher than their genotypic counterpart for all the traits indicating greater environmental influence on these traits for total variation and the magnitude of genotypic and phenotypic coefficient of variation were higher for sugar yield, cane yield, germination % at 45 days, cane height at harvest, no. of milliable cane. Highest value for sugar yield also reported by Anbanandhan & Eswaran (2018) [5] and Gowda *et al.* (2016) [11] while Sanghera *et al*. (2015) reported high phenotypic and genotypic coefficient of variation existed in clones for the trait number of shoots at 240 days followed by cane diameter, single cane weight and number of tillers at 120 days while moderate PCV and GCV were reported by Kumar *et al*. (2018) for the same traits.
Improvement of any characters in a crop depends upon the amount of variability present in the base population, in absence of which there shall be no response to selection. In clonal evaluation, selected clone may influence by the environment for cane and juice quality traits. Heritability estimates are useful in deciding the character to be considered while making selection, but selection based on this factor alone may limit the progress, as it is prone for change with environment, material etc. (Johanson *et al*., 1955). In other words, estimate of heritability have a role to play in determining the effectiveness of selection for a character, provided they are considered in conjugation with the genetic advance as per cent of mean as suggested by Panse (1942) and Johanson *et al*. (1955). As per overview given in Table no. 2 higher heritability estimate were recorded for fiber % at harvest, pol % in juice at 12 month, CCS % at 12 month, brix % at 12 month, germination % at 45 days, pol % in cane, brix at 10 month stage, single cane weight, pol % in juice at 10 month, cane height at harvest, cane diameter at harvest, cane yield, CCS% at 10 month, purity % at 10 month stage, no. of milliable cane at harvest among the twenty characters. Confirmations of same result for higher heritability reported by earlier workers *namely*, Tena *et al*. (2016) [29] recorded for

single cane weight, no. of milliable cane, cane height, pol% in cane, and cane diameter, Tyagi *et al.* (2012) for the traits juice brix %, juice sucrose % and CCS % at 10 and 12 month stage, cane weight and sugar yield per plot and Ali *et al.* (2017) [7] observed for number of milliable cane, plant height at harvest and cane yield, Tedessa and Dilnesaw (2014) [28] reported for cane yield and number of milliable cane and they suggested that the traits expressed high to medium heritability, simple selection would be effective method of sugar cane variety selection since these traits are highly heritable from parents to progenies. In case of genetic advance as percent of mean, high value was recorded for sugar yield at harvest, cane yield, germination % at 45 days, cane height at harvest, single cane weight and fiber % at harvest. Moderate value were observed for cane diameter, brix at 10and 12 month stage, no. of milliable cane, number of tillers at 240 days, number of shoots at 120 days, brix at 12 month, pol % in juice at 12 month, CCS % at 10 month, pol % in cane and CCS% at 12 month stage. Most of the results were also reported by Choudhary (2001) for single cane weight, Agrawal (2003) [2] observed for cane yield and CCS t/ha, Rehman *et al.* (2008) reported for stalk height and cane yield, Sanghera *et al*. (2015) reported for stalk length possess high genetic advance in percent of mean, Tena *et al.* (2016) [29] showed that single stalk weight possess high genetic advance as percent of mean and Tyagi *et al.* (2012) reported for cane height and cane yield.

The result of present study clearly indicated that six characters showed high heritability coupled with high genetic advance as percent of means *namely*, sugar yield, cane yield, germination % at 45 days, cane height, single cane weight at harvest and fiber % at harvest. High heritability coupled with moderate genetic advance as percent of means was observed for no. of milliable cane, pol % in juice at 12 month, CCS % at 10 and 12 month, brix at 12 month stage, cane diameter, brix at 10 month, pol % in juice at 10 month. Similar result were also given by Singh *et al.* (2010) [7] who observed sugar yield at harvest possessed high heritability coupled with higher genetic advance Mali and Patel (2013) observed for CCS t/ha at harvest, single cane, and sugar yield, Hiremath and Nagraja (2016) suggested for cane length, Kumar *et al*. (2017) observed for single cane weight and Kumar *et al.* (2018) also reported for CCSt/ha (sugar yield) and high heritability coupled with moderate genetic advance as percent of mean for cane diameter at harvest and Pandya *et al.* (2016) observed for sugar yield, cane yield and single cane weight.

Now concluded that the presence of additive gene action, clonal selection may be highly effective based on these traits *namely*, sugar yield, cane yield, germination % at 45 days, cane height, single cane weight at harvest and fiber % at harvest might be effective traits for further sugarcane varietal improvement programme.

Table 1: Analysis of variance for twenty characters in thirteen mid late maturing clones of sugarcane

Sl. No.	Characters	Mean sum of squares		
		Replication d.f.=2	Genotype d.f.=11	Error d.f.=22
1	Germination % at 45 days	3.63	91.37**	6.96
2	Number of Shoots (000/ha) at 120 DAP	271.33	358.61**	94.95
3	Number of tillers (000/ha) at 240 days	6.36	368.07**	67.83
4	Number of milliable cane (000/ha) at harvest	125.13	573.74**	88.50
5	Cane height (cm) after 12 months at harvest	771.08	2,630.51**	273.63
6	Cane diameter (cm) after 12 months at harvest	0.03	0.21**	0.02
7	Brix % at 10th month stage	0.22	5.68**	0.49
8	Pol % in juice at 10th month stage	0.28	5.14**	0.47
9	Purity % at 10 month stage	0.75	3.38**	0.58
10	CCS % at 10 month stage	0.32	2.55**	0.28
11	Brix % at 12 month stage	0.52	6.74**	0.45
12	Pol % in juice at 12 month stage	0.45	6.00**	0.39
13	Purity % at 10 month stage	0.75	2.03**	0.66
14	CCS % at 12 month stage	0.27	3.06**	0.20
15	Single cane weight (Kg) at harvest	0.003	0.03**	0.002
16	Fiber % at harvest	2.20	7.26**	0.24
17	Extraction % at harvest	2.40	17.00*	6.03
18	Pol % in cane at harvest	0.64	3.56**	0.30
19	Cane yield (t/ha) at harvest	73.60	642.88**	77.98
20	CCS t/ha (sugar yield) at harvest	1.16	13.80**	1.73

****** 1% level of significance, * 5% level of significance

Table 2: Genetic parameter of twenty characters in mid late maturing sugarcane clones

Sl. No.	Character	σ^2G	σ^2P	GCV	PCV	ECV	h^2	GM
1	Germination % at 45 days	28.14	35.10	14.3	16.23	7.23	80.20	26.80
2	Number of Shoots (000/ha) at 120 DAP	87.89	185.84	8.98	12.95	9.34	48.10	12.83
3	Number of tillers (000/ha) at 240 days	100.08	167.91	8.13	10.53	6.69	59.60	12.93
4	Number of milliable cane (000/ha) at harvest	161.75	250.25	12.03	14.97	8.90	64.60	19.92
5	Cane height (cm) after 12 months at harvest	785.62	1059.26	12.45	14.45	7.35	74.20	22.09
6	Cane diameter (cm) after 12 months at harvest	0.064	0.08	9.77	11.24	5.56	75.50	17.48
7	Brix % at 10th month stage	1.73	2.22	6.75	7.62	3.58	78.00	12.25
8	Pol % in juice at 10th month stage	1.56	2.03	7.24	8.27	4.00	76.60	13.05
9	Purity % at 10 month stage	0.93	1.51	1.10	1.40	0.86	61.70	1.77
10	CCS % at 10 month stage	0.76	1.04	7.34	8.58	4.44	73.30	12.94
11	Brix % at 12 month stage	2.10	2.54	7.01	7.82	3.23	82.50	13.12

12	Pol % in juice at 12 month stage	1.87	2.26	7.52	8.27	3.42	82.90	14.10
13	Purity % at 10 month stage	0.45	1.12	0.77	1.20	0.93	40.80	1.01
14	CCS % at 12 month stage	0.95	1.16	7.78	8.56	3.57	82.60	14.55
15	Single cane weight (Kg) at harvest	0.01	0.01	12.00	13.62	6.45	77.60	21.78
16	Fiber % at harvest	2.34	2.58	11.11	11.67	3.57	90.60	21.80
17	Extraction % at harvest	3.66	9.69	3.32	5.40	4.26	37.80	4.20
18	Pol % in cane at harvest	1.09	1.38	7.06	7.92	3.68	78.60	12.10
19	Cane yield (t/ha) at harvest	189	266.28	17.21	20.46	11.07	70.70	29.81
20	CCS t/ha (sugar yield) at harvest	4.02	5.75	19.76	23.62	12.95	69.90	34.04

Symboll-
GCV= genotypic coefficient of variation, PCV = Penotypic coefficient of variation, ECV = Environmental coeffifient of variation, h^2 = heritability, (σ^2g) = genotypic variance, (σ^2p) = phenotypic variance and GM = Genetic advance at percent mean

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