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Study of Genetic Variability among Midlate Maturing Sugarcane Clones for Different Yield and Juice Quality Traits under Waterlogged Condition

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A B S T R A C T

Genetic variability for twenty five traits were studied in sixteen phenotypically diverse midlate maturing sugarcane clones, which were planted in RBD in three replications at Dr. R.P.C.A.U. Research Farm Pusa Bihar during *spring season* 2016-2017. The study revealed highly significant differences among all clones for all yield attributing and juice quality traits, indicated the ample variation. The magnitude of genotypic and phenotypic coefficient of variation for yield attributing traits were found moderate for germination percentage at 45 DAP, number of shoot at 120 DAP (000/ha), number of millible cane at harvest (000/ha), cane yield (t/ha), sugar yield (CCS t/ha), plant height at 150 DAP, leaf area index before waterlogging, leaf area index at 30 days after waterlogging, leaf area index at 60 days after waterlogging, number of fully emerged leaves at 30 days after waterlogged and number of fully emerged leaves at 60 days after waterlogged. The numerical value of phenotypic variation was higher than their genotypic counterpart for all the characters. The result of present study clearly indicated the importance of traits such as sugar yield (CCS t/ha), cane yield (t/ha), leaf area index before waterlogging, leaf area index at 30 and 60 days after waterlogging as they exerted high genetic advance as percentage of mean coupled with high heritability. These traits were controlled by additive gene action; hence, phenotypic selection could be effective in improvement of such traits.

Introduction

Sugarcane is an important agro-industrial crop of India. It is grown in 5.30 million hectare with total production of 366.8 million tonnes and productivity of 69.1 tonnes/ha. where as in Bihar it is grown in an area of 3.02 lakh hectare with production of 14.90 lakh tonnes and productivity 50 tonnes/ha (2014-15, Indian sugar February, 2016). A considerable area under sugarcane crop in several parts of India is exposed to stagnant water for two to three months during monsoon season. The short fall in yield potential is mainly due to various biotic and abiotic stresses in Bihar in which waterlogging is the main factor because in Bihar about 35-40 per cent of sugarcane area remains waterlogged during monsoon season which coincides with the grand growth period of the crop. To enhance the productivity of this crop in Bihar, there is need to identify such type of sugarcane variety/clone which has ability to tolerate waterlogging condition in Bihar. The cultivated varieties of sugarcane are interspecific hybrids involving at least three

species, *S. officinarum, S. barberi* and *S. spontaneum* which themselves represent complex polyploidy. The chromosome number among varieties varies from 2n = 100 to 120. It is for this reason the sugarcane varieties are botanically described as *Saccharum spp.* complex hybrid. The heterozygous and polyploid nature of this crop has resulted in generation of greater genetic variability. The extent of genetic variability present in any crop is of paramount importance for its improvement. The information on the nature and the magnitude of variability present in the genetic material is of prime importance for a breeder to initiate any effective selection program. Genotypic and phenotypic coefficients of variation along with heritability as well as genetic advance are very essential to improve any trait of sugarcane because this would help in knowing whether or not the desired objective can be achieved from the material (Tyagi and Singh, 1998). So, present study was under taken to assess the extent of genetic variability, heritability, genetic advance of some important traits of midlate sugarcane clones under subtropical India for waterlogging condition.

Materials and Methods

Study areas

The experiment was conducted with sixteen genotypes received from Sugarcane Research Institute, Dr. R.P.C.A.U. Pusa, Samastipur, Bihar during *spring season* 2016-2017. The experimental plot is situated between 25.97^0 N latitude and 85.66^0 E longitudes at 51.80 m above mean sea level.

Treatments and experimental design

The sixteen sugarcane clones *viz.* CoP 09437, CoP 11439, CoP 11440, CoP 12438, CoP 12439, CoP 13438, CoP 13439, CoP 14438, CoP 14439, CoP 15439, CoP 15440, CoP 15441, BO 155 and CoP 2061 were evaluated along with two standard check BO91 and BO154. The trial was laid out in randomized block design with three replications. All the experimental material introduced from SRI, Pusa, Bihar and planted in spring season 2016-2017 under waterloggimg condition. Equal number of three budded set of each clones was planted.

Data collected and analysis

Data were collected for yield attributing traits *viz.* germination percentage at 45 DAP (Days After Planting), number of shoots at 120 DAP. (000/ha), plant height at 150, 240, 360 days (cm), number of fully emerged leaves at 30 days and 60 days after waterlogging, leaf area index before waterlogging, at 30 and 60 days after waterlogging, number of nodes with aerial roots, cane diameter at harvest (cm), number of shoots at 240 DAP (000/ha), number of millable canes at harvest (000/ha), single cane weight (Kg), cane yield (t/ ha) and sugar yield (CCS t/ha) at harvest and juice quality traits *viz.* brix, Pol and Purity at 10 &12 months stage (%), CCS % at 10 and 12 months stage. Chemical analyses of sugarcane juice for brix (%), pol (%), purity (%) and CCS (%) were done. Randomly selected 5 sample cane stalks were crushed with a mini power crusher to get juice for analysis. Brix was determined by Brix hydrometer standardized at 20^0 C and pol % determination was done by taking approximately 100 ml juice of each sample was taken in a beaker and about 1-1.5 gm of basic lead acetate anhydrous was added to it, stirred and kept for some time for the precipitation of the non-soluble substance. The precipitated impurities were filtered off and clear filtrate juice was collected. The clear filtered juice was filled in 20 cm long polarimeter tube. This tube was placed in the body of polarimeter and pol reading was

recorded. Using Schmitz table (Spencer and Meade, 1955), the sucrose percent in juice was noted for corresponding values of the brix and pol reading. CCS % is determined by formula

$$[S-(B-S) \times 0.4] \times 0.73$$

Where,

S = Sucrose percent in juice (pol %).
B = Brix percent in juice.

The data were statistically analyzed. 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). The analysis of variance was used to derive variance components.

Estimation of genotypic and phenotypic coefficient of variation

The formulae used to calculate PCV and GCV were given by Burton and De vane (1953).

Heritability (Broad sense)

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

Genetic advance

The estimates of genetic advance were obtained by the formula given by Lush (1949) and Johnson *et al.,* (1955). The range of genetic advance is classified as suggested by Johonson *et al.,* (1955).

Results and Discussion

As indicated in table 1 it revealed that the analysis of variance for all the 25 characters revealed the highly significant differences among the clones studied. This information indicates that sizable variability exists for all the characters studied and considerable improvement can be achieved in these characters by selection. However the analysis of variance by itself is inconclusive in explaining all the inherent genetic variability in the collection. Effectiveness of selection and identification of superior genotypes depends on the magnitude of inherent variability for a particular character. Hence it is prerequisite to study the estimates of genetic parameters such as coefficients of genotypic and phenotypic variability, heritability and genetic advance.

The extent of variability as measured by GCV and PCV, gives information regarding the relative amount of variation in different characters.

Phenotypic and genotypic coefficient of variation was computed for all the twenty five morphological and juice quality characters indicated in table 2. The numerical value of phenotypic variation was higher than their genotypic counterpart for all the characters. Similar result was reported by Verma and Singh (2002).

The magnitude of genotypic and phenotypic coefficient of variation for morphological traits were found moderate for germination percentage at 45 DAP, number of shoots at 120 DAP (000/ha), number of millible cane at harvest (000/ha), cane yield (t/ha), sugar yield, plant height at 150 DAP, leaf area index before waterlogging, leaf area index at 30 days after waterlogging, leaf area index at 60 days after waterlogging, number of fully emerged leaves at 30 days after waterlogged and number of fully emerged leaves at 60 days after waterlogged. This indicating the presence of moderate genetic variation for these characters. This finding were in accordance to Singh *et al.,* (1996) who also

observed moderate GCV and PCV for number of millable cane and low for brix per cent among sugarcane genotype. Tadesse and Dilnesaw *et al.,* (2014) also reported moderate GCV and PCV for number of millable cane. The characters number of shoots at 240 DAP, number of nodes with aerial roots, cane diameter at harvest, single cane weight, plant height at 240 and 360 DAP had low GCV values indicated that the parental clones used to develop the genotypes under study might possess narrow variability.

Agrawal (2003) also found low GCV for single cane weight. Among the juice quality character, brix, purity, pol and CCS percentage at 10 and 12 months stage respectively had low GCV and PCV values indicating the presence of limited variability for these traits.

The difference between GCV and PCV for quantitative characters e.g. germination percentage at 45 DAP, number of shoot millible cane at harvest (000/ha), cane yield (t/ha), sugar yield (ccs t/ha), single cane weight, leaf area index before and 60 days after waterlogging had narrow implying less influence of environment on the traits. Hence simple selection could lead to better improvement.

The amount of genetic variation alone may not be of more relevance unless it is supplemented with the information on estimates of heritability of a character which provides a measure of effectiveness of selection for that character as it indicates the heritable portion of the total variation.

It has been suggested by Burton and De Vane (1953) that the GCV along with heritability estimate could provide a better picture of degree and magnitude of improvement that can be expected by phenotypic selection. Tadesse *et al.,* (2014) also reported that genotypic coefficient of variation alone is not a correct measure to know the heritable variation present and should be considered together with heritability estimates. Since genetic advance is dependent on phenotypic variability and heritability in addition to selection intensity, the heritability estimates in conjunction with genetic advance values will be more effective and reliable in predicting the response to selection by providing more genetic information on the character.

Knowledge on the heritability of characters is important to the breeders, since it indicates the possibility and extent of improvement that can be achieved through selection for a particular trait. This may be due to the same maturity group of all the clones in study.

As indicated in table 2, Moderate to high heritability estimates were noticed for all the characters studied except number of nodes with aerial roots suggesting that selection of clones for these characters will be effective. Similar result were also reported by Tena *et al.,* (2016), They found high broad sense heritability for stalk diameter, single cane weight, millable cane weight, stalk height and pol %. Gowda *et al.,* (2016) reported that cane yield components *viz.*, sugar yield number of millable cane, single cane weight and cane yield showed high heritability but Their result is slightly different for plant height, stalk diameter, brix percentage pol percentage, purity percentage and CCS percentage, This different might be due to environmental variations in expression of these traits.

As indicated in table 2, Genetic advance as percent of mean were high for sugar yield (CCS t/ha), cane yield, leaf area index before waterlogging, leaf area index at 30 days after waterlogging, leaf area index at 60 days after waterlogging.

Table.1 Analysis of variance for twenty five traits in midlate sugarcane clones under waterlogged conditions

S.No.	Characters	Mean sum of squares		
		Replication (DF=2)	Genotype (DF=15)	Error (df=30)
1.	Germination percentage at 45 DAP	16.60	54.27**	8.94
2.	Number of shoots at 120 DAP (000/ha)	1.98	340.53**	54.62
3.	Number of Shoot at 240 DAP	32.47	496.07**	100.25
4.	Number of millable cane at harvest (000/ha)	1.60	297.86**	47.36
5.	Sugar yield (CCS t/ha).	0.88	5.97**	0.75
6.	Cane yield (t/ha).	20.62	484.28**	43.13
7.	Brix % at 12 months stage.	0.81	1.16**	0.40
8.	Purity % 10 months stage	0.16	1.12**	0.35
9.	Purity % at 12 months stage.	0.34	3.42**	1.23
10.	Pol % at 10 months stage.	0.29	0.86**	0.21
11.	Pol % at 12 months stage.	0.78	1.40**	0.39
12.	Brix % at 10 months stage.	0.33	0.89**	0.16
13.	Number of nodes with aerial roots	0.65	1.15*	0.51
14.	Plants height at 150 DAP (cm)	358.13	414.02**	114.67
15.	Plant height at 240 DAP (cm)	86.11	1708.70**	549.72
16.	Plants height at 360 DAP(cm)	369.99	1798.79**	597.07
17.	Single cane weight (kg)	0.002	0.022**	0.004
18.	Cane diameter at harvest (cm)	0.02	0.14**	0.04
19.	Leaf area index before waterlogging	0.007	0.36**	0.03
20.	Leaf area index at 30 days after waterlogging	0.02	0.46**	0.04
21.	Leaf area index at 60 days after waterlogging	0.06	0.60**	0.06
22.	No. of fully emerged leaves at 30 days after waterlogged	3.06	5.76**	1.28
23.	No. of fully emerged leaves at 60 days after waterlogged	0.08	6.57**	2.06
24.	CCS % at 10 months stage.	0.13	0.50**	0.14
25.	CCS % at 12 months stage.	0.40	0.82**	0.22

* Significant at 5%, ** significant at 1%

Table.2 Genotypic variance, phenotypic variance, genotypic and phenotypic coefficient of variation, heritability, genetic advance and genetic advance as per cent of mean for 25 characters in sugarcane midlate clones under waterlogged condition

Sl.N0.	Characters	Range	σ2g	σ2ph	GCV (%)	PCV (%)	Heritability	Genetic advance	Genetic advance as per cent of mean
1.	Germination percentage at 45 DAP	30.33-44.50	15.11	24.05	10.26	12.94	62.81	6.35	16.75
2.	Number of shoots at 120 DAP (000/ha)	77.33-110.33	95.30	149.92	10.22	12.81	63.57	16.03	16.78
3.	Number of Shoot at 240 DAP	115.00-160.33	131.95	232.17	8.17	10.84	56.83	17.83	12.69
4.	Number of millable cane at harvest (000/ha)	60.00-95.19	83.50	130.86	11.05	13.83	63.81	15.04	18.18
5.	Cane yield (t/ha).	5.99-9.81	147.05	190.18	17.56	19.96	77.32	21.97	31.80
6.	Sugar yield (CCS t/ha).	49.00-88.79	1.74	2.49	16.66	19.96	69.73	2.27	28.67
7.	Plants height at 150 DAP (cm)	18.23-20.07	99.78	214.46	11.63	17.05	46.53	14.04	16.35
8.	Plant height at 240 DAP (cm)	86.57-88.67	386.33	936.04	9.67	15.05	41.27	26.01	12.50
9.	Plants height at 360 DAP(cm)	86.03-89.57	400.57	997.64	9.29	14.65	40.15	26.13	12.12
10.	Number of nodes with aerial roots	15.10-17.29	0.21	0.73	7.43	13.71	29.31	0.51	8.28
11.	Single cane weight (kg)	15.90-17.97	0.006	0.010	9.38	11.96	61.43	0.13	15.14
12.	Cane diameter at harvest (cm)	17.40-19.50	0.03	0.08	7.64	11.68	42.83	0.24	10.31
13.	Leaf area index before waterlogging	5.33-7.33	0.11	0.14	16.23	18.54	76.53	0.60	29.22
14.	Leaf area index at 30 days after waterlogging	67.11-108.66	0.14	0.18	13.89	15.80	77.26	0.68	25.15
15.	Leaf area index at 60 days after waterlogging	167.52-247.50	0.18	0.24	13.50	15.73	73.73	0.75	23.89
16.	No. of fully emerged leaves at 30 days after waterlogged	182.66-261.33	1.49	2.78	13.20	18.00	53.70	1.84	19.92
17.	No. of fully emerged leaves at 60 days after waterlogged	0.71-1.01	1.50	3.56	11.38	17.52	42.14	1.64	15.21
18.	Brix % at 10 months stage.	2.05-2.78	0.24	0.40	2.70	3.48	60.52	0.79	4.33
19.	Purity % 10 months stage	1.51-2.71	0.26	0.61	0.58	0.89	42.45	0.68	0.78
20.	Pol % at 10 months stage.	2.01-3.18	0.21	0.43	2.90	4.13	49.34	0.67	4.19
21.	CCS % at 10 months stage.	2.21-3.75	0.12	0.26	3.17	4.63	46.99	0.49	4.48
22.	Brix % at 12 months stage.	7.00-11.67	0.25	0.66	2.65	4.27	38.61	0.64	3.40
23.	Purity % at 12 months stage.	8.00-13.67	0.73	1.96	0.98	1.60	37.28	1.08	1.23
24.	Pol % at 12 months stage.	10.36-12.07	0.34	0.73	3.48	5.12	46.11	0.81	4.86
25.	CCS % at 12 months stage.	10.92-12.50	0.20	0.42	3.89	5.64	47.42	0.63	5.51

It was moderate for germination percentage at 45 DAP, number of shoots at 120 and 240 DAP (000/ha) respectively, number of millable cane at harvest (000/ha), plant height at 150, 240 and 360 DAP respectively, indicating the role of dominant genetic effect in determination of these characters and its improvements. These results are in conformity with the observation of Singh *et al.*, (1996) for traits cane yield, cane diameter, cane height and number of millable cane. But the present investigation is slightly different from finding of Kumar *et al.,* (2001) for traits number of millable cane and single cane weight these different results might be due to environmental difference. Bairwa *et al.*, (2017) found moderate genetic advance as percent of mean for trait cane diameter these finding are in agreement with present investigation.

The result of present study clearly indicated the importance of traits such as sugar yield (CCS t/ha), cane yield (t/ha), leaf area index before waterlogging, leaf area index at 30 and 60 days after waterlogging as they exerted high genetic advance as percentage of mean coupled with high heritability indicated that these traits were controlled by additive gene action; hence, phenotypic selection could be effective in improvement of such traits. These finding are in agreement with Jain *et al.*, (2001) for single stalk weight and cane yield and Kumar *et al.,* (2004) also found similar result for cane yield.

In conclusion, the wide range of variation was observed for all the characters studied. Genotypes differed significantly for all the characters. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were found to be separated very narrowly. This indicates that little influence by the environment. The moderate PCV and GCV value was recorded for the leaf area index before waterlogging, number of fully emerged leaves at 30 day after waterlogging, number of fully emerged leaves at 60 day after waterlogging, leaf area index at 30 days after waterlogging, leaf area index at 60 days after waterlogging, number of milliable cane at harvest, germination percentage at 45 DAP and number of shoots at 120DAP, Therefore, GCV and PCV values indicated that selection may be effective based on these traits for selection or rejection among candidate genotypes. However the juice quality traits exhibited low GCV and PCV.

The greatest heritability in broad sense was exhibited by cane yield while lowest was purity % at 12 months stage. All traits *viz.*, cane yield, leaf area index at 30 days after waterlogging, leaf area index before waterlogging, leaf area index at 60 days after waterlogging, sugar yield, number of millable cane at harvest, number of shoots at 120 DAP, germination percentage at 45 DAP, single cane weight and brix % at 10 months stage showed high genetic heritability in broad sense.

High heritability coupled with high genetic advance as percent of means was observed for cane yield, leaf area index at 30 days after waterlogging, leaf area index before waterlogging, leaf area index at 60 days after waterlogging and sugar yield, suggesting the preponderance of additive genetic effect in the determination of these traits. It also indicated that selection for these traits will be effective and require careful selection for desired improvements in the traits.

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