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Correlation among Yield, Quality and Mechanization Amicable Traits in Sugarcane Clones

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this study was to identify superior clones suitable for mechanical harvesting, which is essential to improve the production efficiency, cost effectiveness, cane loading efficiency infield losses and also to investigate the relationships among the yield and quality parameters with cane yield and sugar yield in sugarcane. This experiment was conducted at Regional sugarcane and Rice Research Station, Rudrur, Nizamabad district, Telangana state in Randomized Block Design (RBD) with three replications. The analysis of variance revealed significant differences among

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genotypes for fifteen yield, quality and mechanization amicable characters. Correlation coefficient results indicated that cane yield was positively correlated with commercial cane sugar, number of tillers at 120 days after planting, cane height, cane girth, single cane weight. So, selection for cane yield alone will also increase the other characters because these traits are positively correlated with cane yield. The Angle of inclination is negatively correlated with cane yield and positively correlated with ratio of crown weight to cane weight, brix%, sucrose%, purity% and CCS%. Results indicate that the genotypes should be selected on the basis of number of millable canes, cane length, cane girth and single cane weight for getting higher sugarcane yield. Furthermore, mechanization amicable genotypes can be selected which are near to erect nature and also having less crown weight.

Keywords: Cane yield; correlation; commercial cane sugar; angle of inclination; sugarcane.

1. INTRODUCTION

"Sugarcane (*Saccharum spp.*) is an important agro-industrial commercial crop of India which plays a vital role because of its wider adaptability over varying agro climatic conditions and also unique among agricultural crops in the sense that 2-3 succeeding cane crops are raised from a single planting which is an integral component of sugarcane production system. Sugarcane (*Saccharum sp.*) is cultivated in about 5.9 million hectares with a total cane production of 490.53 million tons. The country's average cane yield hovers around 83.30 tons per hectare. In Telangana, sugarcane is cultivated on 28,000 ha with a total production of 2.94 million tons. The average cane yield in Telangana is 105 tons per hectare" [1].

"Sugarcane is labour intensive requiring about 3300 man-hrs per hectare for different operations" [2]. In view of the facts that mechanization of sugarcane crop culture would solve the ever increasing problems of scarcity of labour, cost of cultivation, drudgery and timely completion of cultural operations, development of mechanization amicable varieties is inevitable for improving the cane productivity per unit time, area and energy. Furthermore, identification of superior clones suitable for mechanical harvesting is essential so as to improve the production efficiency, cost effectiveness, cane loading efficiency infield losses and also encourage the sugarcane growers towards cane cultivation. The correlation studies are used to measure the intensity and direction of character association. Since selection is usually concerned with improving a group of characters simultaneously, an understanding of inter se correlations is of prime interest of the breeder. Hence, in the present investigation an attempt is made to understand the type of association existing between sugarcane yield, quality and mechanization amicable characters.

2. MATERIALS AND METHODS

Experimental design: The present study comprised thirteen sugarcane genotypes were evaluated at Regional Sugarcane and Rice Research Station, Rudrur, Nizamabad, Telangana during the year 2021-22 cropping season under black cotton soil, following Randomized block design with 3 replications. The plot size is of 1.2 m x 6 m long in four rows. The planting was done at 12 buds per meter row length. All the recommended cultural practices were followed to obtain a good crop.

Data collection: The data were recorded as per standard statistical procedures for yield, quality attributes and mechanization amicable parameters viz. Germination, Tillers count at 120 days and 240 days after planting, Number of millable Canes, Brix, Sucrose, Purity, Commercial Cane Sugar%, Cane length, Cane girth, Single Cane weight, Cane Yield and Commercial Cane Sugar yield, mechanization amicable characters angle of inclination, ratio of crown weight to cane weight. Yield components, such as germination count, number of tillers at 240 days after planting, number of millable canes, cane length, cane girth and single cane weight were evaluated for each genotype. The number of millable canes was counted within each plot. For the determination of the cane length, a measurement tape was used to measure a sample of ten canes. A vernier caliper was used to measure the diameter of the same ten canes, which the reading region was defined as one third of the cane height (from the basis to the top). Then, the ten canes were weighed, and the mean weight was obtained. The cane productivity was calculated from the weight of all millable canes per plot and the area occupied by each plot (t/ha). Brix was estimated with a hydrometer from juice extracted from 5-stalks samples per plot in the laboratory in the month of

November. POL estimated using a polarimeter. Angle of inclination is measured using protractor for a sample of ten canes. Crown weight and cane weight ratio is measured by using the top crown weight and the cane weight. Crown weight is weight of the left-over crown portions of canes after harvesting the crop.

Statistical analysis: 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 the Panse VG and Sukhatme PV [3]. The analysis of variance was used to derive variance components Cochran WG and Cox GM [4]. Correlation coefficient analysis was calculated as per formulae suggested by Dewey DR and KH Lu [5].

3. RESULTS AND DISCUSSION

Coefficient of variation: The analysis of variance revealed significant differences among genotypes for all the plant characters (Table 1). The PCV (phenotypic coefficient of variation) and GCV (genotypic coefficient of variation) values are ranked as low, medium, and high with 0 to 10%, 10 to 20%, and >20%, respectively [6]. The estimated phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for thetraits indicating greater environmental influence on these traits for total variation. Low PCV values were exhibited by Cane length (5.31), Cane girth (9.53), Brix % at 12months stage (7.99), Sucrose% at 12 month stage (8.27), Purity% at 12 months stage (3.13), CCS% at 12 month stage (8.76). Medium PCV for germination percentage (16.25), number of tillers at 120 days after planting (13.40), number of shoots at 240 days after planting (13.40), number of millable canes (13.40) and high PCV for Cane yield (28.75), CCS yield at harvest (31.45), angle of inclination (21.06), Ratio of crown weight to cane weight (29.84) and single cane weight (26.64) were recorded (Table2).

Heritability: The evaluation of heritable variation with the help of genetic coefficient of variation alone may be deceptive. Therefore genotypic coefficient of variation is not a correctmeasure to know the heritable variation presentand should be considered together withheritability.Heritability values are categorized as low(0–30%), moderate (30–60%), and high (60%and above). Low and medium heritability values were notobtained in this study. High heritability wasexhibited by all the traits. So, selection breeding for improvement of these varieties based these traits may be reliable. But heritability alone provides no indication of the amount of genetic improvement that would result from selection of individual genotype. Thus, information of heritability should be coupled with genetic advance.

Genetic advance (GA): Genetic advance is referred as the improvement of characters in genotypic value forthe new population compared with the base population. Genetic advance as per cent mean is categorized as low (0-10), moderate (10-20) and high (>20). The genetic advance expressed as per cent of mean was high for Cane yield (57.41), CCS yield (63.32), Angle of inclination (42.31), Crown Wt/Cane Wt (53.99), Germination percentage (21.77), Tillers at 120 days after planting (25.73), Shoots at 240 days after planting (25.73), number of millable canes (25.74) and signle cane weight (54.25). The high heritability coupled with high genetic advancewas obtained for Cane yield, CCS yield, Angle of inclination, Crown Wt/Cane Wt, Germination percentage, Tillers at 120 days after planting, Shoots at 240 days after planting, number of millable canes and signle cane weight. Thus, these characters are under the control of additive genetic effects and it confirms that selection based on the phenotypic performance of this trait is best for variety improvement program.

Correlation: “Cane yield is associated with its various components genotypically and phenotypically in various magnitudes. Further, their study has indicated the magnitude of the correlations among cane yield traits. In general, genotypic correlation coefficients were higher than their corresponding phenotypic correlation coefficients indicating a fairly strong inherent relationship among the traits. The lower estimates of phenotypic correlation indicated that the relationships were affected by environment at phenotypic level. Such environmental influence in reducing the correlation coefficients in rice” was also reported by Chaudhary and Singh [7]. The correlation coefficient results (Table 3) indicated that the cane yield was positively and significantly correlated with commercial cane sugar (0.96***), number of tillers at 120 days after planting (r=0.46**), number of shoots at 240 days after planting (0.46**), millable canes (r=0.46**), cane height (r=0.47**), cane girth (r=0.35*), single cane weight (r=0.93***). The Angle of inclination is negatively correlated with cane yield and positively correlated with ratio of

Table 1. Analysis of variance results for yield, quality and mechanization amicable traits in sugarcane

Source of Variations	df	Germination %	No of tillers @ 240 DAP	No of shoots @ 240 DAP	No of millable canes	Brix%	Sucrose%	Purity%	CCS%	Cane Length (cm)	Cane Girth (cm)	Single Cane Weight (Kg)	Cane Yield (T/ha)	CCS Yield (T/ha)	Angle of Inclination	Crown Wt / Cane Wt
Replications	2	53.76	15.10	12.66	10.47	0.013	0.0002	0.22	0.0012	3.27	0.0008	0.00003	18.36	0.32	0.08	0.0001
Treatments	12	122.15	601.90	505.79	418.03	8.72	7.65	22.60	4.18	442.79	0.22	0.26	2484.74	54.79	425.96	0.0035
Error	24	18.57	14.16	11.90	9.83	0.04	0.0012	0.59	0.0014	11.53	0.002	0.001	26.16	0.42	3.65	0.0002

CCS-Commercial Cane Sugar

Table 2. Genetic parameters for fifteen yield, quality and mechanization amicable traits of sugarcane clones

S.No.	Genotypes	Coefficient of variation		Heritability (Broad sense %)	Genetic advance (GA)	Genetic advance as percent of the mean (%)
		Genotypic	Phenotypic			
1	Cane Yield (T/ha)	28.31	28.75	0.97	58.05	57.41
2	CCS Yield (T/ha)	31.09	31.45	0.97	8.67	63.32
3	Angle of Inclination	20.80	21.06	0.98	24.13	42.31
4	Crown Wt / Cane Wt	27.97	29.84	0.87	0.06	53.99
5	Germination %	13.10	16.25	0.65	9.76	21.77
6	No of tillers @ 120 DAP	12.94	13.40	0.93	27.85	25.73
7	No of shoots @ 240 DAP	12.94	13.40	0.93	25.53	25.73
8	No of millable canes	12.94	13.40	0.93	23.21	25.74
9	Cane Length (cm)	5.10	5.31	0.93	23.76	10.13
10	Cane Girth (cm)	9.39	9.53	0.97	0.55	19.07
11	Single Cane Weight (Kg)	26.49	26.64	0.98	0.61	54.25
12	Brix%	7.93	7.99	0.99	3.48	16.20
13	Sucrose%	8.27	8.27	1.00	3.29	17.03
14	Purity%	3.01	3.13	0.93	5.37	5.97
15	CCS%	8.76	8.76	0.99	2.43	18.04

Table 3. Genotypic and phenotypic correlation coefficient for yield, quality and mechanization amicable traits in sugarcane

		Cane Yield	CCS Yield	Angle of Inclination	Crown Weight/ Cane Weight	Germination %	Tillers @ 120 DAP	Shoots @240 DAP	No of Millable Canes	Cane Length	Cane Girth	Single Cane Weight	Brix% 12M	Sucrose% 12M	Purity % 12M	CCS% 12M
Cane Yield	**P**	**1.00**	0.96***	-0.42**	0.17	0.23	0.46**	0.46**	0.46**	0.47**	0.35*	0.93***	0.27	0.25	-0.06	0.23
	G	**1**	0.96	-0.46	0.14	0.30	0.45	0.45	0.45	0.50	0.37	0.94	0.26	0.25	-0.03	0.24
CCS Yield	**P**		**1.00**	-0.30	0.26	0.16	0.38*	0.38*	0.38*	0.40*	0.16	0.93***	0.48**	0.51***	0.11	0.50**
	G		**1**	-0.32	0.25	0.21	0.36	0.36	0.36	0.42	0.16	0.93	0.48	0.51	0.14	0.51
Angle of	**P**			**1.00**	0.02	-0.15	-0.34*	-0.34*	-0.34*	-0.60***	-0.28	-0.38*	0.20	0.21	0.09	0.20
Inclination	**G**			**1**	-0.03	-0.17	-0.36	-0.36	-0.36	-0.63	-0.29	-0.40	0.19	0.21	0.13	0.21
Crown Weight/	**P**				**1.00**	0.17	0.12	0.12	0.12	0.01	-0.25	0.17	0.30	0.35*	0.17	0.35*
Cane Weight	**G**				**1**	0.23	0.10	0.10	0.10	-0.001	-0.28	0.15	0.29	0.36	0.26	0.38
Germination%	**P**					**1.00**	0.40*	0.40*	0.40*	-0.15	0.009	0.10	0.06	-0.05	-0.31	-0.09
	G					**1**	0.51	0.51	0.51	-0.25	-0.01	0.14	0.10	-0.05	-0.47	-0.12
Tillers 120 DAP	**P**						**1.00**	1.00***	1.00***	0.51***	0.04	0.12	-0.10	-0.07	0.02	-0.05
	G						**1**	1.00	1.00	0.55	0.05	0.12	-0.11	-0.07	0.03	-0.05
Shoots 240	**P**							**1.00**	1.00***	0.51***	0.04	0.12	-0.10	-0.07	0.02	-0.05
DAP	**G**							**1**	1.00	0.55	0.05	0.12	-0.11	-0.07	0.03	-0.05
No of Millable	**P**								**1.00**	0.51***	0.04	0.17	-0.10	-0.07	0.02	-0.05
Canes	**G**								**1**	0.55	0.05	0.12	-0.11	-0.07	0.03	-0.05
Cane length	**P**									**1.00**	0.13	0.33*	-0.04	-0.02	0.03	-0.008
	G									**1**	0.09	0.35	-0.04	-0.02	0.03	-0.009
Cane Girth	**P**										**1.00**	0.34*	-0.45**	-0.54***	-0.35*	-0.55***
	G										**1**	0.35	-0.46	-0.54	-0.37	-0.56
Single Cane	**P**											**1.00**	0.37*	0.35*	-0.05	0.32*
Weight	**G**											**1**	0.37	0.35	-0.02	0.33
Brix% 12M	**P**												**1.00**	093***	-0.01	0.86***
	G												**1**	0.94	0.02	0.87
Sucrose%12M	**P**													**1.00**	0.35*	0.99***
	G													**1**	0.37	0.99
Purity % 12M	**P**														**1.00**	0.49**
	G														**1**	0.50
CCS% 12M	**P**															**1.00**
	G															**1**

crown weight to cane weight, brix%, sucrose%, purity% and CCS%. The increase in cane yield was due to combined effect of stalks per stool, length of stalk and weight per stool concluded by Chaudhry [8].

A Positive and highly significant correlation between cane yield and its components viz., single stalk weight, stalk length and millable cane number was reported by Bora et al. [9] and Gowda et al. [10]. The correlation of number of millable canes with cane length was positive, whereas single cane weight showed negative correlation with tiller numbers (Table 3). Cane yield is in positive correlation with Number of Millable Canes at harvest reported by Kheniet al. [11] and Reddy et al. [12]. In case of sugar yield positive correlation was observed with cane yield, cane weight, number of millable canes, cane length, cane girth, Brix%, sucrose %, CCS % and purity % and non-significant correlation was observed with cane girth.

Sugar yield per hectare is mainly dependent on cane yield, Brix%, Sucrose%, purity % and CCS %. 12 reported positive and significant association of sugar yield with number of tillers at 120 days after planting (r=0.38*), number of shoots at 240 days after planting (0.38*), millable canes(r=0.38*), cane height(r=0.40*), single cane weight (r=0.93***), Brix% (0.48**), sucrose % (0.51***) and CCS% at 12 month (0.50**). The negative correlation of purity% and angle of inclination with cane yield is one of the major constraints in the improvement of sugarcane (Table 3). Our results are in agreement with those mentioned byKumar and Kumar [13] and Tadesse and Dilnesaw [14], who found that the caneyield, consideredas the most important character of sugarcane, was positively and significantly correlated with number of millable canes, stalk diameter and stalk weight. Moreover, they noted negative associations of cane yield with juice pol, and purity%.

Sucrose% had the positive correlation with Brix (r= 0.93**) and ration of crown weight to cane weight (r= 0.35*) and negative correlation with cane girth (r= - 0.54***). Similarly, the correlation of Brix was highly significant with CCS% (r= 0.86***).Our data showed negative significant correlation between cane yield and any of the sucrose-related traits. Tyagi et al. [15] also found “a strong negative correlation between Brix, sucrose percent, purity percent in juice and cane yield/plot. This could be attributed to the difference in length of growth and time of sampling for sucrose traits”. Boraet al. [9] found that “sugar recovery had a high and significant correlation with field brix and sucrose [16-19]. Hence these two characters must be given importance for improvement of sugar recovery. This study revealed that higher cane length, cane girth endowed with better single cane weight are the important characters which should be considered while selection to be made for higher sugar yield in sugarcane genotypes” [20-22].

4. CONCLUSION

The study indicated that there is wide range of genetic variability among the tested clones for growth and yield characters. It is evident that the high heritability coupled with high genetic advance reported in characters Cane yield, CCS yield, Angle of inclination, Crown Wt/Cane Wt, Germination percentage, Tillers at 120 days after planting, Shoots at 240 days after planting, number of millable canes and signle cane weight. Hence, selection of the best performing clones based on these characters may be utilized in future selection breeding programme. A perusal of the results of correlation analysis revealed that cane yield was positively and significantly correlated with commercial cane sugar, number of tillers at 120 days after planting, number of shoots at 240 days after planting, millable canes, cane height, cane girth, single cane weight. Sugar yield per hectare was positive and significant association with number of tillers at 120 days after planting, number of shoots at 240 days after planting, millable canes, cane height, single cane weight, Brix%, sucrose % and CCS% at 12th month. The Angle of inclination is negatively correlated with cane yield and positively correlated with ratio of crown weight to cane weight, brix%, sucrose%, purity % and CCS%. Hence, emphasis should be given to these traits while formulating selection criteria for improvement in cane, sugar yield and mechanization amicable characters.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image

generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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