

CORRELATION STUDIES OF AGRONOMIC TRAITS FOR HIGHER SUGAR YIELD IN SUGARCANE

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Abstract

Twelve sugarcane clones were used in this study. The analysis of variance revealed significant differences among genotypes for all the plant characters. Highest cane yield (144 t/ha) was recorded in clone NIA82-1026P5 and highest Pol % (20.82) and CCS % (16.45) were observed in CP84-1198. Correlation coefficient results indicated that cane yield was positively correlated with cane girth, weight per stool, sugar yield, tiller numbers and purity % whereas Pol % and CCS % showed negative correlation with cane yield. Sugar yield showed non significant correlation with cane girth.

Introduction

Sugarcane belongs to the *Poaceae* family and is being propagated by stem cuttings (Khan *et al.*, 2009). It contributes 70% of the raw sugar produced world-wide, the remaining 30% obtained from sugar beet (Butterfield *et al.*, 2001; D'Hont & Glaszmann, 2001). Sugar yield of Pakistan is around 4 tons per hectare which is very low as compare to the cane growing countries, having yields of 6 to 13 tons per hectare (Khan *et al.*, 2010). Cane yield and sucrose content are two important characters for obtaining high sugar yield (Terzi *et al.*, 2009). Zhu *et al.*, (2000) reported that cane yield and sucrose content and their interaction are important parameters for developing superior genotypes. Olaoye (1995) observed that stepwise multiple regression analyses using cane yield and sucrose % as dependent variables indicated that four characters viz., field emergence, stalks/stool, stalk length and stalk diameter could account for 31 to 53% variation in cane yield and sucrose content.

In the present study correlation analyses of data collected on agronomic and morphological characters on 12 sugarcane clones were used to determine (i) the relationship of these characters with cane yield and sucrose content and (ii) ascertain their contribution in obtaining high sugar yield in sugarcane.

Materials and Methods

Twelve sugarcane clones were used. Experimental layout was RCB design with 4 replications. The plot size was 8 x 10 m, row to row distance was one meter. The sowing was done in the month of September 2008 and 2009 and normal agronomic practices were followed throughout the growth period. Observations were recorded for 7 important agronomic characters viz., tillers (No), weight per stool (kg), Pol %, fiber %, purity %, cane yield (t/ha) and sugar yield (t/ha). Three stools were randomly taken from each plot to determine sugar contents according to sugarcane laboratory Manual for Queensland Sugar Mills (Anon., 1970) while 3 rows from each plot were harvested to record yield data. The mean and variance were computed from each treatment. Data on one plant crop and two ratoon crop was computed on

above mentioned parameters. Data were analysed following Steel & Torrie (1980).

Results and Discussion

The analysis of variance revealed significant differences among genotypes for all the plant characters (Table 1). Results regarding the mean performance of the genotypes for cane yield and its components showed significant ($p \leq 0.05$) differences amongst the clones (Table 2). Clone NIA82-1026P5 produced significantly highest cane yield (144.67 t/ha) followed by NIA-81-0819P5 (133.67 t/ha) and NIA-2004 (113.33 t/ha). The lowest cane yield was observed in commercial variety BL4 (60 t/ha) (Table 2). As regard cane girth (cm), BL 4 (3.20) was at the top followed by CP84-2114 (3.12), CP84-1198 (2.98) and CP86-1086 (2.94), while minimum girth was observed in CP43-33 (2.12). Weight per stool (kg) was highest in NIA-2004 (11.33) and minimum weight per stool was observed in BL4 (6.0). Significant differences were observed for number of tillers per plant. The maximum tillers were observed in NIA81-0819P5 and BL4 (7.67), whereas minimum in CP84-1198 (5.67).

Mean values of different clones for pol %, CCS %, purity % and sugar yield t/ha were significantly different at $p \leq 0.05$ (Table 2). Significantly highest pol % and CCS % were observed in CP84-1198 (20.83 & 16.45 respectively) followed by L116 (19.86 & 15.39 respectively). Minimum pol% was observed in CP84-2114 (16.12) while minimum CCS% was observed in CP86-1086 (12.08). Maximum sugar yield (t/ha) was obtained by NIA81-0819P5 (18.97) followed by NIA82-1026P5 (17.81) and NIA-2004 (16.54). Commercial variety BL4 produced the lowest sugar yield (8.04 t/ha). Maximum purity % was observed in CP84-1198 (92.43) followed by NIA-2004 (88.94) and minimum was observed in NIA82-1026P5 (83.11).

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 & Singh (1994). The correlation coefficient results (Table 3) indicated that the cane yield was positively correlated with cane girth ($r=0.412^*$), weight per stool ($r = 0.4.87^*$), sugar yield ($r = 0.924^{**}$), tiller numbers ($r=0.826^{**}$) and purity% ($r=0.487^*$). The pol % and CCS % were negatively correlated with cane yield. Chaudhry (1982) concluded that the increase in cane yield was due to combined effect of stalks per stool, length of stalk and weight per stool. According to Raman *et al.*, (1985) number of stalks per stool was a major yield contributing factor followed by height and cane girth. Singh & Sharma (1983) concluded

that cane yield exhibited phenotypic association with stalks per stool. Our results are in agreement with these workers as far as contribution of stalks per stool to cane yield is concerned. Khan *et al.*, (1997) reported non significant correlation between stalks per stool and cane yield. The correlation of tillers per plant with weight per stool ($r = 0.758^*$) was significant, whereas purity %, pol % and CCS % showed negative correlation with tiller numbers (Table 3). In case of sugar yield strong positive correlation was observed with cane yield, cane weight, tiller numbers, pol %, CCS % and purity % and non significant correlation was observed with cane girth.

Table 1. Analysis of variance of sugarcane clones.

Source	DF	SS	MS	F
Replicate	2	0.2150	0.10751	
Genotype	11	78.2991**	7.11810**	11.29**
Error	22	13.8728	0.63058	
Total	35	92.3869		

Table 2. Average performance of sugarcane clones for seven important agronomic traits.

Clone	Tiller (no.)	Weight/stool (kg.)	Cane girth (cm)	Cane yield (t/ha)	CCS (%)	Purity %	Pol (%)	Sugar yield (t/ha)
NIA2004	6.67ABCD	11.33A	2.69	113.33C	14.593BC	88.937AB	18.967B	16.54B
Thatta-10	6.33BCD	8.67BC	2.70	86.67D	12.630E	86.540BC	16.737D	10.91D
NIA82-1026P5	7.00ABC	8.00BCDE	2.89	144.67A	12.323E	83.117C	16.623D	17.81AB
NIA81-0819 P5	7.67A	8.17BCD	2.68	133.67B	14.173BCD	85.197BC	18.597BC	18.97A
CP84-1198	5.67D	8.50BCD	2.98	85.00DE	16.450A	92.430A	20.827A	13.99C
CP86-1086	6.00CD	8.83B	2.94	88.33D	12.080E	84.457BC	16.470D	10.67D
CP86-1632	7.00ABC	7.17DEF	2.56	71.67FG	14.747BC	86.907BC	19.443B	10.58D
NIAS3	7.33AB	6.67EF	2.55	66.67GH	12.917DE	85.953BC	17.187D	8.59E
L116	7.00ABC	7.33CDEF	2.23	73.33FG	15.393AB	88.930AB	19.860AB	11.27D
BL4	7.67A	6.00F	3.20	60.00H	13.397CDE	86.950BC	17.363CD	8.04E
CP84-2114	6.67ABCD	8.00BCDE	3.12	80.00DEF	12.150E	85.743BC	16.120D	9.73DE
CP43-33	7.33AB	7.67BCDE	2.12	76.67EF	12.690E	86.297BC	17.057D	9.77DE
SD value	1.2124	1.4434	NS	9.4452	1.4820	5.4235	1.3446	1.9407

Table 3. Genotypic and phenotypic correlation among seven important traits of sugarcane.

Characters	Variation	Pol %	CCS %	Purity %	Tiller (No.)	Weight (kg)	Cane girth	Cane yield
Pol (%)	Genotypic							
	Phenotypic							
CCS (%)	Genotypic	0.997						
	Phenotypic	0.987						
Purity %	Genotypic	0.740	0.852					
	Phenotypic	0.730	0.816					
Tiller (no.)	Genotypic	-0.124	-0.123	-0.532				
	Phenotypic	-0.223	-0.203	-0.349				
Weight (kg.)	Genotypic	0.137	0.126	0.281	0.881			
	Phenotypic	0.111	0.103	0.155	0.758			
Cane girth (cm)	Genotypic	0.410	0.236	0.748	0.123	0.143		
	Phenotypic	0.398	0.214	0.712	0.029	0.101		
Cane yield (t/ha)	Genotypic	-0.539	0.085	0.533	0.889	0.533	0.458	
	Phenotypic	-0.402	-0.054	0.487	0.826	0.487	0.412	
Sugar yield	Genotypic	0.472	0.443	0.582	0.564	0.582	0.256	0.943
	Phenotypic	0.426	0.419	0.520	0.512	0.523	0.213	0.924

Sugar yield per hectare is mainly dependent on tillers per plant, cane yield, pol % and CCS %. Sangwan & Singh (1983) reported positive and significant association of sugar yield with brix %. The negative correlation of pol% and CCS % with cane yield and positive correlation with sugar yield is one of the major constraints in the improvement of sugarcane (Table 2).

For plant breeders, yield in crops is one of the most important and complex traits. Continued improvement of yield remains the top priority in most breeding programs (Cox *et al.*, 1996). Brix% and cane yield in sugarcane depends on various growth and component traits, which is the final outcome of a combination of different yield components, such as cane girth, stalk number per stool, stalk weight and pol % (Olaoye, 1995). Many component analyses have been performed for complex traits based on morphological and physiological characterizations (Liu *et al.*, 1984; Bull *et al.*, 2000; Petrasovits *et al.*, 2007). It could be more effective that yield components were selected to increase yield because of lower heritability for yield and higher heritability for yield components (Hogarth, 1971). However, yield is correlated with yield components in complicated ways (Risch, 2000; Darvasi & Pisanté-Shalom, 2002). Therefore, it is imperative to reveal the genetic relationship between yield and its component traits and their interaction to various environments. This study revealed that higher number of tillers, good weight, endowed with better pol %, CCS % and purity % are the important characters which should be considered while selection to be made for higher sugar yield in sugarcane genotypes.

References

- Anonymous, 1970. *Sugarcane Laboratory Manual for Queensland Sugar Mills*, Bureau of Sugar Experimental Station, Queensland 2, 9th Edition.
- Bull, T. 2000. The Sugarcane Plant. In "*Manual of cane growing*". (Eds.): M Hogarth & P Allsopp. Bureau of Sugar Experimental Stations, Indooroopilly, Australia. pp 71-83
- Butterfield, M.K., A. D'Hont and N. Berding. 2001. The sugarcane genome: a synthesis of current understanding, and lessons for breeding and biotechnology. *Proc. Soc. Afr. Sugarcane Technol. Ass.*, 75: 1-5.
- Chaudhary, P.K. and R.P. Singh 1994. Genetic variability, correlation and path analysis of yield components of rice. *Madras Agric. J.*, 81(9): 468-470.
- Chaudhry, B.A. 1982. Fertilizer and dolomitic lime requirements of some sugarcane soil in Negros occidental, Philippines. Ph. D. Dissertation, Univ. of Philippines, Los Banos, Philippines.
- Cox, M.C., T.A. McRae, J.K. Bull and D.M. Hogarth. 1996. Family selection improves the efficiency and effectiveness of a sugarcane improvement program. In: *Sugarcane: Research towards Efficient and sustainable production*, (Eds.): D.M. Hogarth, J.A. Campbell and A.L. Garside. pp. 287-290.
- D'Hont A. and J.C. Glaszmann. 2001 Sugarcane genome analysis with molecular markers, a first decade of research. *Proc Int Soc Sugarcane Technol.*, 24: 556-559.
- D'Hont, A., D. Ison, K. Alix, C. Roux and J.C. Glaszmann. 1998. Determination of basic chromosome numbers in the genus *Saccharum* by physical mapping of ribosomal RNA genes. *Genome*, 41: 221-225.
- Darvasi, A. and A. Pisanté-Shalom. 2002. Complexities in the genetic dissection of quantitative trait loci. *Trends Genet.*, 18(10): 489-491.
- Hogarth, D.M. 1971. Quantitative inheritance studies in sugarcane: II. Correlations and predicted responses to selection. *Aust. J. Agric. Res.*, 22(1): 103-109.
- Khan, I.A., M.U. Dahot, N. Seema, S. Yasmine, A. Khatri and M.H. Naqvi. 2009. Direct regeneration of sugarcane plantlets: a tool to unravel genetic heterogeneity. *Pak. J. Bot.*, 41(2): 797-814.
- Khan, I.A., S. Bibi, S. Yasmin, A. Khatri, N. Seema and S. Afghan. 2010. Study of genetic variability in mutated population of sugarcane clone NIA-98 through molecular markers (RAPD and TRAP). *Pak. J. Bot.*, 42(1): 605-614.
- Liu, M.C., Yeh, H.S. and Chen, W.H. 1984. A high-sucrose and vigorously growing calliclone 71: 4829. *Rep. Taiwan Sugar Res. Inst.*, 102: 1-11.
- Olaoye, G. 1995. Evaluation of local sugarcane accession II determinants of cane yield and sucrose content. *Nigeria Journal Genet.*, 10: 23-30.
- Petrasovits, L.A., M.P. Purnell, L.K. Nielsen and S.M. Brumbley. 2007. Production of poly hydroxy butyrate in sugarcane. *Plant Biotechnology Journal*, 5: 162-172.
- Raman, K., S.R. Bhat and B.K. Tripathi. 1985. Ratooning ability of sugarcane genotypes under late harvest conditions. *Indian Sugar*, 35: 445-448.
- Risch, N.J. 2000. Searching for genetic determinants in the new millennium. *Nature*, 405(6788): 847-856.
- Sangwan, R.S. and S. Singh. 1983. Correlation and path coefficient analysis of commercial character in sugarcane (*Saccharum* species complex). *Indian Sugar Crops. J.*, 9(1): 7-9.
- Singh, H. and H.L. Sharma. 1983. Path coefficient analysis of cane yield in sugarcane. *Indian Sugar Crops. J.*, 9(2): 7-9.
- Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. McGraw-Hill Book, New York.
- Terzi, F.S.P., F.R. Rocha, R.Z.N. Vencio, J.M. Felix, D.S. Branco, A.J. Waclawovsky, L.E.V.D. Bem, C.G. Lembke, M.D.L. Costa, M.Y. Nishiyama, R. Vicentini, M.G.A. Vincentz, E.C. Ulian, M. Menossi and G.M. Souza. 2009. Sugarcane gene associated with sucrose content. <http://www.biomedcentral.com/1471-2164/10/120> *BMC Genomics*, 10(120):
- Zhu, Y.J., H.H. Albert and PH. Moore. 2000. Differential expression of soluble acid invertase genes in the shoots of high-sucrose and low-sucrose species of *Saccharum* and their hybrids. *Australian Journal of Plant Physiology*, 27: 193-199.

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