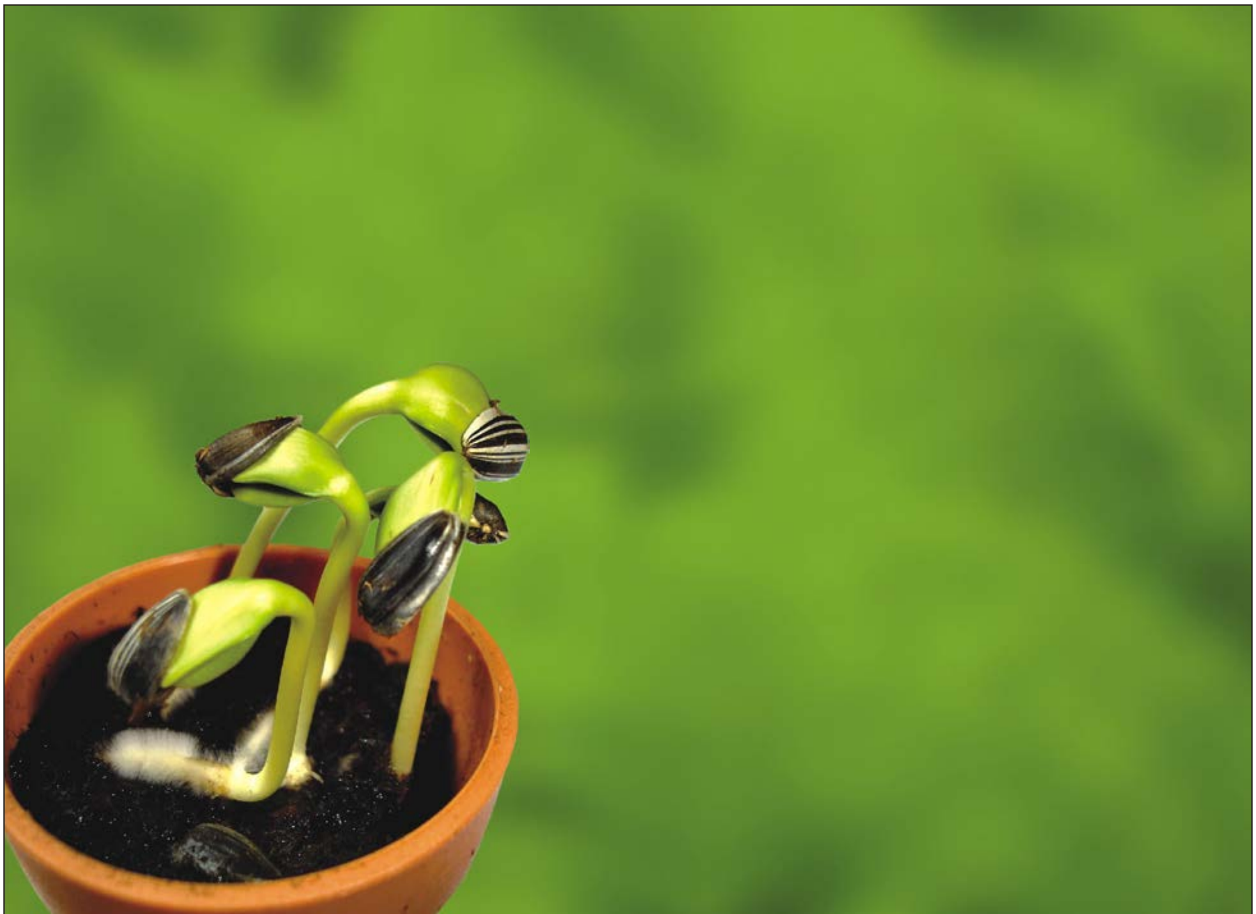

International Journal of Plant Breeding and Genetics

ISSN 1819-3595

Academic Journals Inc.

www.academicjournals.com

International Journal of Plant Breeding and Genetics 5 (1): 93-98, 2011
ISSN 1819-3595 / DOI: 10.3923/ijpbg.2011.93.98

Genotype x Environment Interaction and Stability Analysis in Elite Clones of Sugarcane (*Saccharum officinarum* L.)

D.K. Tiawari, P. Pandey, R.K. Singh, S.P. Singh and S.B. Singh
UP Council of Sugarcane Research, Shahjahanpur-242001, Uttar Pradesh, India

Corresponding Author: D.K. Tiwari,UP Council of Sugarcane Research, Shahjahanpur-242001, Uttar Pradesh, India

ABSTRACT

The present investigation was undertaken to identify the stable cultivars across different environmental condition. Sixteen early maturing and elite genotypes of sugarcane were evaluated for their adoptability in respect of cane yield and its components for three years from 2004-2007 under two plants and one ratoon crops. The stability of genotypes was estimated by using the method of Eberhart and Russell In this analysis sum of square due to G x E were portioned into individual genotypes (X-i), regression of environmental means (bi) and deviation from regression (S^2d). The regression coefficients (bi) and mean square deviation from regression (S^2d) were used to define genotype stability. Significantly mean square differences among Genotypes x Environment for all the characters were observed, this is indication of significant variability among the experimentation. The mean square due to G x E were significant for NMC, length of internode, sucrose % in juice and CCS%. Higher mean values for sucrose percent in juice were found in the genotypes CoS05263, CoS05249 and CoS05259 was superior to others. The stability parameters for NMC, cane yield, sucrose % and CCS% shown by the genotype CoJ64 compared to UP05233, CoS05266, CoS05260, CoS05276 and CoS05263 indicated better adoption and less sensitive to environmental changes. From the present study it is concluded that for cane yield and sucrose % in juice in UP05233 and CoS05263 performance better then rest of elite genotypes study due to having high mean values of genotype over all three environments. Therefore, these genotypes may be commercially cultivated over a wide range of environments.

Key words: Sugarcane, clones, G x E interaction, stability, yield and quality parameter

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the major cash crops grown extensively all over in the world from tropical to sub tropical regions. India is the second largest producer of sugarcane next to the Brazil (FAO Database, 2004). Generally sugarcane is a vegetatively cultivated crop with wide adoptability and diversity. In subtropical India variation in climatic conditions are wide in the period of its growth and maturity, here, temperature ranges from 0-48°C, photoperiod ranges from 4-8 h, humidity from 8-100%. Climatic coefficient shifts are variable factors during the crop growth period which affect the yield and other characters of the crop. Hence, the yield of sugarcane is generally low in this part of India. Sugarcane breeding is highly complex because of its highly heterozygous nature, combined with higher polyploidy (2n = 80 to 120). In multi-year yield trials, sugarcane breeders are aware about the differences of its cultivars for yield and quality which varies from region to region. This arises many questions like, do be require different cultivars for different environment or should be select specific cultivars for particular environment. Further, the ranks of these genotypes vary from one location to another location, indicating a strong Genotype x environment interaction. Genotype x environment (GxE) interactions is a widely recognized phenomenon in sugarcane clonal selection trials (Kang and Miller, 1984; Jackson and Hogarth, 1992; Kimbeng *et al.*, 2002).

Genotype by environment interactions are important sources of variation in any crop and the term stability is sometimes used to characterize a genotype, which shows a relatively constant yield, independent of changing environmental conditions. On the basis of this idea, genotypes with a minimal variance for yield across different environments are considered stable (Sabaghnia *et al.*, 2006). In other words it shows high buffering ability of the population (Gupta *et al.*, 1977).

The stability methods can be divided into two major groups: univariate and multivariate stability statistics (Lin *et al.*, 1986). Knowledge on the components of the genotype environment (GxE) interaction is of great importance for genetic breeding but provides no detailed information on the performance of each cultivar under varying environmental conditions (Cruz *et al.*, 2004). The analyses of adaptability and stability are therefore extremely important and necessary for the identification and recommendation of superior genotypes in different environments. Different biometrical methods have been used for Genotype x Environment interaction in crop plants by several workers the important once being Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968), Freeman and Perkins (1971) and centroid analysis (Rocha *et al.*, 2005). Most of them give information mostly about the genotype (varieties), constitution and role of mega environment. Therefore, it is necessary to evaluate genotype for G x E interaction for yield and its attributes and identify stability for these traits in sugarcane. Sufficient information regarding stability parameters is not available in sugarcane which could be used in further breeding programme for crop improvement. Kipping above factors in view, the present investigation was undertaken to evaluate Genotype x Environment interaction and stability analysis in elite clones of sugarcane.

MATERIALS AND METHODS

The present experiment was carried out with sixteen early maturing genotypes of sugarcane in three different environments to test the stability of genotypes. The detail of genotypes was presented in Table 1. Further the genotypes were laid out in randomized block design having 3 replications in each environment during three years (2004 to 2007) at the Sugarcane Research Institute, Shahjahanpur-U.P. (India). The first and second crop plant was planted under Spring planting in second week of February and harvested in March at 13 month stage and ratoon of plant crop was taken to judge the rationing ability of the genotypes during 2006-07. The plot size for each genotype consists of 5 rows of 7.0 m length, space at 90 cm. The crop received 150: 60: 40 kg ha^{-1} NPK in plant crop and 180: 60:40 kg ha^{-} NPK in ratoon crop. Total quantity of phosphorus and potassium was applied at basal while nitrogen was given at three equal splits at germination, tillering and final ear thing up. All the culture practices were adopted during the entire cropping season to ensure good crop. The fertilizer, irrigation and cultural practices were adopted as per research recommendations (Kerala Agricultural University, 2002). The valuable examined were viz., Number of Millable Cane (NMC), internode length, cane yield, Commercial Cane Sugar Percent (CCS%) in December as per standard methods (Mathur, 1981). Ten fully grown stalks randomly selected from each plot for juice analysis.

Table 1: Detail of the sugarcane genotypes used under present investigation

Genotypes	Percentage
UP05233	CoSe92423 x UP9742
CoS03268	CoS94257 GC
CoS05249	UP9530 x UP9529
CoS05266	CoS87216 x Co8213
CoS04259	CoH56 PC
CoS05250	CoS92254 x Co1148
CoS04250	CoLk8102 x Co62198
CoS05263	CoS91230 x Co1148
CoS05265	CoS87216 x Co1148
CoS05262	CoS91230 x Co1148
CoS05264	CoS95255 x Co1148
CoS05259	CoS90269 x Co8213
CoS03276	CoH76 PC
CoS05260	CoS90269 x Co89003
CoS0687	Co976 x Co312
CoJ64	Co976 x Co617

The stability of genotypes was estimated by using the method of Eberhart and Russell (1966). In this analysis sum of square due to G x E were portioned into individual genotypes (X-i), regression of environmental means (bi) and deviation from regression (S^2d). The regression coefficients (bi) and mean square deviation from regression (S^2d) were used to define genotype stability. The environmental mean was the mean of all genotypes in each environment. The pooled error was used to test the hypothesis that the mean square deviation did not differ significantly from 0 at 0.05 and 0.01% probability levels. The t-test employing the standard error of regression coefficient against the hypothesis that it did not differ from 1.0. It was assumed that genotype effects were fixed and year effects were random.

RESULTS AND DISCUSSION

The pooled analysis of variance revealed that environment, genotypes and genotype x environment interaction (G x E) were significant for all the variables (Table 2). The higher value of pooled deviation than the pooled error indicated that there was a relationship between non linear regression components and elite genotypes for cane yield and sucrose percent in juice during November. The relationship strengthens the conclusion that genotypes responded differently a cross environments for cane yield and sugar content. Similar results were also reported by Tai *et al.* (1982) for sugarcane in Florida.

The G x E interaction is guide problematic for plant breeding because the means of genotypes over several locations are not much reliable for predicting the performance of genotypes of a particular genotype. Therefore, in such situation genotypes should be targeted to individual specific locations to maximize cane yield and total sugar yield. Further, the infractions contents noise which complicates matter for cultivar recommendation (Gauch, 1990; Gauch-Jnr, 2006; Ebdon and Gauch, 2002).

Mean performance, regression (bi) and mean square deviation for regression (S^2d) were presented in Table 3; the data revealed that high mean values, regression coefficients close to unity and least square deviations for NMC in Co05263, UP05233 and Cos05266. The results identify these genotypes having stable NMC under varying environments elite genotype Cos05263

Table 2: Analysis of variance pooled across three environments for yield and quality traits in 16 early maturing sugarcane genotypes

		Mean sum of squares				
Sources	df	NMC	Length of internode	Cane yield	Sucrose % in juice (Nov)	CCS% (Dec)
Genotypes (G)	15	131.59**	4.47**	1112.82**	1.14*	1.00*
Environment (E)	2	25717.4**	5.07**	9430.27**	0.41*	0.47*
G x E	30	418.14**	1.92*	245.23**	0.19*	0.21*
E + (G x E)	32	1999.34**	2.12*	819.29**	0.20*	0.22*
E (Linear)	1	51434.66**	10.14**	18860.60**	0.83*	0.94*
G x E (Linear)	15	675.96**	0.86*	434.06**	0.11*	0.38*
Pooled deviation	16	150.30**	2.79*	52.86**	0.25*	0.03
Pooled error	90	195.56	0.67	180.43	0.04	0.02

**Indicate significance at 1% level of significant. *Indicate significance at 5% level of significant

Table 3: Pooled analysis of early maturing elite sugarcane genotypes for yield and quality traits

	NMC			Length of internode			Cane yield			Sucrose % in juice			CCS %		
Genotypes	X-i	Bi	S^2d	X-i	bi	S^2d	X-i	Bi	S^2d	X-i	bi	S^2d	X-i	bi	S^2d
UP05233	208.89	-0.11	24.52	12.09	-1.12	1.72	182.44	1.06	-31.69	16.07	2.85*	0.07	11.51	5.65**	-0.01
CoS03268	167.44	1.16	-57.28	12.80	0.34	1.11	127.22	1.16	-12.79	15.52	0.94	0.13	11.07	3.39**	0.03
CoS05249	153.22	1.45	39.82	14.48	0.36	23.40	135.22	0.60	25.98	16.74	1.19	-0.01	12.35	-0.59	0.16
CoS05266	194.22	1.24	96.53	11.38	1.89	2.26	153.56	1.19	-56.06	15.22	4.50**	-0.01	10.64	0.00	-0.01
CoS04259	172.67	1.20	-34.23	12.85	2.04	2.12	157.33	0.92	-27.89	16.05	0.42	0.31	11.77	-0.86	0.06
CoS05250	150.33	1.39	-61.92	14.72	-0.05	0.21	119.89	-0.08	-32.03	14.91	0.16	0.29	12.10	2.62*	0.01
CoS04250	160.22	0.77	11.45	10.66	1.13	-0.20	127.89	1.21	13.30	16.21	0.68	0.13	11.81	-4.47	-0.01
CoS05263	236.56	1.16	-4.16	13.16	-0.80	-0.01	145.89	1.77	-27.36	16.96	-2.00	0.09	12.64	2.63*	0.02
CoS05265	169.78	1.00	7.10	12.66	2.63*	-0.23	164.89	0.84	37.98	14.91	2.93*	0.09	11.24	-0.19	0.06
CoS05262	178.00	1.48	58.74	12.27	1.88	4.37	162.00	2.55*	8.20	15.72	-0.68	0.60	11.29	-0.62	0.00
CoS05264	172.00	1.28	7.84	10.85	2.00	2.01	147.00	0.53	-52.43	15.62	0.53	-0.02	10.97	1.37	-0.01
CoS05259	172.22	0.37	-57.70	12.64	1.01	1.15	160.67	1.34	-47.41	16.37	0.04	2.12	12.52	2.51*	-0.01
CoS03276	179.33	1.39	20.53	11.51	2.10	-0.11	148.89	0.74	99.31	15.56	0.64	0.62	11.15	4.02**	0.01
CoS05260	181.67	1.20	-51.98	12.73	0.15	0.29	165.22	1.27	98.65	15.57	1.66	-0.01	11.68	-1.52	0.01
CoS0687	194.00	0.51	30.50	12.77	2.34*	1.02	118.22	0.45	-59.48	15.97	1.34	-0.01	11.69	-0.70	-0.01
CoJ64	169.22	0.53	16.79	10.39	0.10	1.97	121.89	0.46	-52.77	16.70	0.78	0.04	12.08	2.72**	0.16

**Indicate significance at 1% level of significant. *Indicate significance at 5% level of significant

(higher sugar content with early in maturity) shows higher mean values, regression coefficient higher than unity (2.63) and deviation from regression near to zero (0.02) which was numerically higher than that UP05233. Similar to NMC the stability parameter for cane yield and quality characters in sugarcane showed that the genotypes UP05233 and CoS05263 were identified high values of NMC and sucrose percent in juice and the genotypes UP05233 and CoS05260 were stable for cane yield (Table 3). The differential behaviour of sugarcane genotypes for the production of millable canes was attributed to varying potential of different genetic make ups to exploit environmental resources. These results were in agreement with the results of Anjum (1991) and Hunsigi and Krishna (1998).

Although, quality characters are more genetical rather than environment, the same is reflected by the way of getting numerically minimum deviation from regression for most of the elite sugarcane genotypes. Higher mean values for sucrose percent in juice were found in the genotypes CoS05263, CoS05249 and CoS05259 was superior to others. Only in high performance in environments and its quality decreases drastically in poor environment. Therefore these genotypes should not be recommended for planting in all environments. Because farmers are more interested in the cultivars that produce consistent yields under their growing conditions and breeders want to meet these needs (Mulema *et al*., 2008).

The stability parameters for NMC, cane yield , sucrose % and CCS% shown by the genotype CoJ64 compared to UP05233, CoS05266, CoS05260, CoS05276 and CoS05263 indicated better adoption and less sensitive to environmental changes. Although, CoS05263, CoS05249 had a relative high mean performance for sucrose % in juice in November. The stability parameters (bi and S^2d) indicated that quality characters were widely adapted to changing environments. As a check variety, to compare with selected genotypes Cos687 and CoJ64 might be very effective and satisfactory stability for quality improvement programme.

Eberhart and Russell (1966) defined a stable variety as one with a regression coefficient is unity (b = 1) and a minimum deviation from regression (S^2d = 0). From the present investigation it is concluded that the early maturing genotypes UP05233 and CoS05263 had identified as promising genotypes satisfying the above requirements for stability with high mean values of cane yield, high sucrose % in juice and CCS%. Therefore, these genotypes may be commercially cultivated over a wide range of environments.

ACKNOWLEDGMENT

The first author is highly thankful to Shri S.B.Singh; director U.P. council of Sugarcane Research, Shahjahanpur, U.P. (India), for their constant support and providing necessary facilities for this project.

REFERENCES

Anjum, M.U.H., 1991. Study on spring ratooningability and yield potential of some sugarcane cultivars. M.Sc. Thesis, Agriculture Department of Agronomy, Univ. Agric. Faisalabad.

Cruz, C.D., A.J. Regazzi and P.C. Carneiro, 2004. Biometric Templates Applid to Genetic Improvement. UFV, Viçosa, Brazil, pp: 480.

Ebdon, J.S. and Jr. H.G. Gauch, 2002. Additive main effect and multiplicative interaction analysis of national turfgrass performance trials. II Cultivar recommendations. Crop Sci., 42: 497-506.

Eberhart, S.A. and W.A. Russell, 1966. Stability parameters for comparing varieties. Crop Sci., 6: 36-40.

FAO Database, 2004. Area, production and yeld of major sugar-cane producing countries. http://www2.bioversityinternational.org/publications/pgrnewsletter/tables/table4-148.htm.

Finlay, K.W. and G.N. Wilkinson, 1963. The analysis of adaptation in a plant breeding programme. Aust. J. Agric. Res., 14: 742-754.

Freeman, G.H. and J.M. Perkins, 1971. Environmental and genotype-environmental components of variability. VIII. Relations between genotypes grown in different environments and measures of these environments. Heredity, 27: 15-23.

Gauch, H.G., 1990. Using Interaction to Improve Yield Estimates. In: Genotype-by-Environment Interaction and Plant Breeding, Kang, M.S. (Eds.). Department of Agronomy, Louisiana State University, Baton Rouge, Louisiana, pp: 141-150.

Gauch-Jnr, H.G., 2006. Statistical analysis of yield trials by AMMI and GGE. Crop Sci., 46: 1488-1500.

Gupta, V.P., A.S. Khera and K.S. Bains, 1977. Concepts in Stability Analysis. In: Genetics and Wheat Improvement, Gupta, A.K. (Eds.). Oxford and IBH Publishing Co., New Delhi.

Hunsigi, G. and K.R. Krishna, 1998. Science of Field Crops. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, pp: 328-352.

Jackson, P.A. and D.M. Hogarth, 1992. Genotype x environment interactions in sugarcane. I. Patterns of response across sites and crop-years in North Queensland. Aust. J. Agric. Res., 43: 1447-1459.

Kang, M.S. and J.D. Miller, 1984. Genotype x environment interactions for cane and sugar yield and their implications in sugarcane breeding. Crop Sci., 24: 435-440.

Kerala Agricultural University, 2002. Package of Practices Recommendations: Crops. 12th Edn., Kerala Agricultural University, Trichur, pp: 278.

Kimbeng C.A., A.R. Rattey and M. Hetherington, 2002. Interpretation and implications of genotype by environment interactions in advanced stage sugarcane selection trials in central Queensland. Aust. J. Agric. Res., 53: 1035-1045.

Lin, C.S., M.R. Binns and L.P. Lefkovitch, 1986. Stability an alysis: Where do we stand. Crop Sci., 26: 894-900.

Mathur, R.B.L., 1981. Handbook of Cane Sugar Technology. 2nd Edn., Oxford and IBH Publisher Co. Ltd., Janapath, New Delhi, pp: 680.

Mulema, J.M.K., E. Adipala, O.M. Olanya and W. Wagoire, 2008. Yield stability analysis of late blight resistant potato selections. Exp. Agric., 44: 145-155.

Perkins, J.M. and J.L. Jinks, 1968. Environmental and genotype-environmental component of variability. III. Multiple lines and crosses. Heredity, 23: 339-356.

Rocha, R.B., J.I.M. Abad, E.F. Araujo and C.D. Cruz, 2005. Rating dométodo centroid for the study of environmental adaptation of clones of Eucalyptus grandis. For. Sci. Santa Maria, 15: 255-266.

Sabaghnia, N., H. Dehghani and S.H. Sabaghpour, 2006. Nonparametric methods for interpreting genotype x environment interaction of Lentil genotypes. Crop Sci., 46: 1100-1106.

Tai, P.Y.P., E.R. Rice, V. Chew and J.D. Miller, 1982. Phenotypic stability analyses of sugarcane cultivar performance tests. Crop Sci., 22: 1179-1184.