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Short Research Article

Phenotypic Stability in Sugarcane (*Saccharum officinarum* L.) Through Different Classical Parametric Measures under Saline-Alkali Condition

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Abstract

Fifteen early and mid late sugarcane genotypes were evaluated for their phenotypic stability under four different environments under saline-alkali condition in respect of cane yield and its component characters through different parametric stability models. The stability parameters (X, bi and S^2di) for cane yield and its component characters revealed that the genotypes BO 146 was stable in wide range of environments for cane yield and number of millable canes, while, BO 147 and BO 141 were found most stable for cane yield, germination percent at 45 DAP, number of shoots at 120 DAP, number of millable canes in favourable environments and its attributes and less sensitive to environmental change. The genotype BO 110 was showed good germination percent at 45 DAP and number of millable canes in poor environments. The S.F. value nearest to unity for cane yield was observed for BO 146 followed by BO 136, BO 110, BO 144 and BO 109 while, for number of millable canes BO 146 was recorded S.F. value nearest to unity followed by the genotypes BO 110, BO 144, BO 137 and CoP 9702. The estimated ecovalence revealed that the genotypes, BO 139, CoP 022, CoP 9702 and BO 109 showed high mean for cane yield and exhibited low 'Wi' values which indicated that these genotypes had contributed minimum towards genotype×environment interaction component. The present investigation revealed that the genotypes, BO 147, BO 146 and BO 136 were identified as better sugarcane varieties for changing environments.

1. Introduction

The loss of plant productivity due to the excess of salinity is a worldwide problem where the soil and water resources dictate the production of sugarcane crop. It was reported that globally 1 mha of sugarcane area experience varying degree of salt problem (Gomathi and Dhandapani, 2004). In India, approximately one third of sugarcane cultivable area affected due to salinity. Better to improve the productivity of sugarcane and it can be achieved through reclamation of saline lands or growing tolerant sugarcane genotypes. Reclamation of saline land is time taking and costly affair and hence there is an urgent need of identifying suitable tolerant genotypes with high yielding and better quality characteristics under saline environment.

The aim of breeder is to evolve varieties which may give maximum economic yield over different environment and consistent performance. Productivity of a population is the function of its adaptability while the later is a compromise of fitness (stability) and flexibity. Stability may, infect depend on holding certain morphological and physiological attribute and allowing others to vary, resulting in predictable genotype× environment interaction for the ultimate traits i.e. the yield. A population which can adjust its genotypic or phenotypic state in response to environmental fluctuation in such a way that it gives high economic return can be termed as well buffered. Genotype×environment interactions are a widely recognized phenomenon in sugarcane varieties selection (Kimbeng et al., 2002). Genotype×environment interactions are most important sources of variation and the term stability is 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 the environments are considered stable

(Sabaghnia et al., 2006). Sugarcane crop is known to be influenced by the environmental variations. Hence, testing of varieties in different environments is necessity to identify varieties possessing least interaction with the environments. The present investigation was therefore undertaken to assess the yield stability over environments in relation to component traits through different parametric stability models.

2. Materials and Methods

The present experiment was carried out with fifteen genotypes of sugarcane of two maturity groups early and mid late in four environments to test the stability of genotypes. The details of genotypes are presented in Table 1 which was developed at Sugarcane Research Institute (SRI), Rajendra Agricultural University, Pusa, Bihar centre. These genotypes were planted in a randomized block design with three replications four environments in autumn and spring planting season viz., autumn planting-normal soil (E_1), spring planting-normal soil (E_2), autumn planting-saline soil (E_3) and spring planting-saline soil (E_4). The plot size was 3.0×4.0 m^2 with row to row distance is 90 cm in experimental plot (Pangabri field) of ICAR Sub-station, Crop Research Programme, Pusa, Bihar and New Area Farm of Sugarcane Research Institute, Pusa.

Table 1: List of fifteen genotypes of sugarcane, their maturity and parentage

Sl. No.	Genotypes	Maturity	Parentage
1.	BO 91	Mid late	BO 55×BO 43
2.	BO 99	Early	Co 1207×BO 43
3.	BO 109	Mid late	Co 1193×BO 32
4.	BO 110	Mid late	Co 1193×BO 50
5.	BO 130	Early	BO 91×BO 43
6.	BO 136	Mid late	BO 89 FC
7.	BO 137	Mid late	BO 106 FC
8.	BO 139	Early	BO 109×BO 143
9.	BO 141	Mid late	BO 89 FC
10.	BO 144	Early	BO 106 FC
11.	BO 145	Early	BO 110×BO 121
12.	BO 146	Mid late	BO 128×BO 109
13.	BO 147	Mid late	BO 110 self
14.	CoP 022	Mid late	BO 91×HR83-144
15.	CoP 9702	Mid late	BO 99×NCO 310

Observations were recorded for eight quantitative characters viz., germination percent at 45 days after planting (DAP), cane diameter (cm), plant height (cm), single cane weight (kg) and leaf area index, number of shoots (000 ha^{-1}) at 120 days after planting, number of millable canes and cane yield (t ha^{-1}). The three juice quality characters (brix, sucrose and purity), commercial cane sugar percent (CCS%) and extraction percent were recorded in the month November, December and January. Stability analysis for grain yield and its components traits were carried out following parametric models viz. Lewis (1954), Wricke (1962); Eberhart and Russell (1966).

3. Results and Discussion

It is evident from analysis of variance (Table 2), that there were highly significant differences among genotypes, and environment for all the characters studied except cane diameter, single cane weight leaf area index, sucrose % , CCS% and extraction percent in the middle of November, December and January, when tested against pooled error suggesting the presence of variation among the genotypes. The genotype and environment interaction were significant for germination at 45 days after planting, number of middle canes, plant height and cane yield. It may, therefore be inferred that the genotypes interacted considerably with the environments in the expression of the characters. The partioning of environment+G×E interaction into different components revealed that the environment (linear) was significant for germination at 45 days after planting, number of shoots at 120 days after planting, number of middle canes, plant height and cane yield indicating the responsiveness of the sugarcane genotypes and their performance can be predicted with same reliance over the environments. Similar findings were reported by Sanjeevkumar et al. (2007); Tiwari et al. (2011); Tahir et al. (2013); Guddamath et al. (2014) in sugarcane genotypes.

The results confirm the findings of effect in comparison to genotype×environment (linear) for all the traits which may be responsible for high adoption in relation to yield attributing traits, Similar results for yield components were reported by Bhatnagar and Khan (1993); Tyagi et al. (2001); Nahar and Khaleque (2001) reported stability model based on linear function while, Goswami and Borah (1995); Rosse et al. (2002) recommended non-linear model.

Finlay and Wilkinson (1963) reported linear regression as a quantitative measure of phenotypic stability to denote varietal adaptability over arrange of environment. But Eberhart and Russell (1966) suggested both linear (bi) and non-linear (S^2di) of the genotype×environment should be considered while evaluating the phenotypic stability of genotypes. G×E (linear) interaction was significant for germination at 45 days after planting, number of shoots at 120 days after planting, plant height and cane yield, whereas, non–significant for number of milliable canes.

Table 2: Analysis of variance of fifteen sugarcane genotypes for eleven traits across the four environments

Source of variation	d.f.	Mean Square						
		Germination at 45 DAP (%)	No. of shoots (000 ha^{-1}) at 120 DAP	No. of millable canes (000 ha^{-1}) at harvest	Cane diameter (cm) at harvest	Plant height (cm)	Single cane wt. (kg) at harvest	Leaf area index in the middle of August
Genotype	14	43.32**	823.36**	631.35**	0.21	3874.29**	0.03	0.65
Environment	3	113.13**	195.65**	172.23**	0.15	579.25**	0.01	0.06
Genotype×environment	42	3.96**	6.18**	4.85**	0.00	9.67**	0.00	0.02
Pooled error	112	1.48	30.78	20.99	0.01	82.22	0.00	0.01

Source of variation	Cane yield (t ha^{-1}) at harvest	Mean Square								
		Sucrose % in the middle of			CCS % in the middle of			Extraction % in the middle of		
		Nov.	Dec.	Jan.	Nov.	Dec.	Jan.	Nov.	Dec.	Jan.
Genotype	515.27**	0.62	0.89	0.49	0.83	0.57	0.31	58.68	54.98	37.43
Environment	435.58**	0.24	1.52	2.82	82.59	1.19	1.66	49.06	64.75	67.52
Genotype×environment	7.17**	0.26	0.23	0.19	0.21	0.15	0.10	0.49	0.87	1.33
Pooled error	9.17**	0.04	0.05	0.04	0.02	0.02	0.03	1.21	1.29	1.26

*Significant at p=0.05; ** at p=0.01

3.1. Cane yield (t ha^{-1})

The results (Table 3) revealed that the genotypes BO147 (93.07 t ha^{-1}) recorded the highest cane yield followed by BO146 (84.61 t ha^{-1}), BO141 (83.62 t ha^{-1}) and BO136 (73.82 t ha^{-1}) and it was higher than average cane yield (68.79 t ha^{-1}). The genotype BO 147 and BO 146 recorded higher cane yield mean with non-significant S^2di and bi value near to unity indicating its good stability for cane yield with varying environmental condition. However, the genotype BO 141 exhibited higher mean cane yield, non-significant S^2di but regression value above unity indicating its responsiveness to favourable environment. The genotype Bo 136 recorded above average cane yield (68.79 t ha^{-1}), regression value below unity with non-significant S^2di indicates the responsiveness to the favourable environment.

3.2. Number of milliable canes (000 ha^{-1}) at harvest

The genotypes BO 141, BO 147 and CoP 9702 were better in favourable environment as they had regression coefficient (biE) greater than one and significant, their S^2di was non-significant. The genotype BO 146 showed higher mean value, bi value nearer to unity and non-significant S^2di indicating average responsiveness to the environmental fluctuations for number of millable canes at harvest. Hence the genotype BO 146 is suitable for all the environments. The genotypes, BO 99 and BO 110 were low responsive and recorded the higher mean for number of milliable canes 000' ha^{-1} (107.06) than grand mean. Therefore, these two genotypes are recommended for poor environment.

3.3. Number of shoots (000' ha^{-1}) at 120 days after planting (DAP)

The genotypes BO 147 (136.31), BO 146 (122.83), BO 99 (121.58) and BO 136 (111.91) recorded the higher number of shoots '000' ha^{-1} at 120 days over general mean (105.11). These genotypes recorded non-significant S^2di and their biE value greater than unity it means that the above varieties are more responsive for favourable environment. The genotypes BO 110 and Bo 136 had regression coefficient numerically approaching to one and not significant S^2di, indicating more buffering capacity of the variety and characterized by less environmental change.

3.4. Germination percent at 45 days after planting

The genotypes, BO 147, BO 136 and Cop 9702 were better in average environment (autumn and spring normal) as they had regression coefficient (biE) greater than one and significant deviation from regression (S^2di) was not significant. It means that BO 147, BO 136 and Cop 9702 had better germination in favourable environments. The genotypes, BO 109 and BO 91 recorded non- significant S^2di and biE value nearer to one, indicating non-responsive to the environmental fluctuation indicating their stability to average environment for germination percent at 45 days after planting. The genotypes, Bo 110 and BO 145 performed better in poor environment as they had significant regression coefficient biE less than one and their deviation from regression (S^2di) was not significant.

3.5. Plant height (cm)

The genotype BO 147 (290.10 cm), BO 141 (271.05 cm), CoP 022 (259.72 cm) and BO 136 (248.10) and it was higher than the average plant height. The genotypes BO 141, BO 136 and BO 147 recorded above average plant height (251.86 cm) with non-significant S^2di and biE value near to unity indicating their good stability in varying environmental condition. The genotype BO 143 eviation of S.F. from unity, the less stable is the genotype. But this parameter is highly sensitive to the response of genotype to extreme environment and relies more on consistently in performance with two consideration of absolute yield potential. In the present investigation S.F. showed significant and positive asociation with bi and S^2di. Similar results were reported by Prasad and Singh (1980), while working on maize. The S.F. value (Table 3) nearest to unity for cane yield was observed for BO 146 followed by BO 136, BO 110, BO 144 and BO 109 while, for number of millable canes BO 146 was recorded S.F. value nearest to unity followed by the genotypes BO 110, BO 144, BO 137 and CoP 9702. Stability factor nearest to unity for number of shoots after 120 days after planting was observed by the genotype BO 109 followed by BO 136, BO 144 and BO 146

Table 3: Estimates of stability parameters for different characters in sugarcane

Geno-types	Germination percent at 45 days after planting					No. of shoots (000 ha^{-1}) at 120 days after planting					No. of millable canes (000 ha^{-1}) at harvest				
	X	bi	S^2di	Wi	S.F.	X	bi	S^2di	Wi	S.F.	X	bi	S^2di	Wi	S.F.
BO 91	32.23	1.250	-0.831	2.69	1.19	108.72	0.366	-29.439	18.44	1.01	80.26	1.006*	-20.605	0.77	1.06
BO 99	30.63	0.083	0.178	22.03	1.00	121.58	1.148**	-28.021	6.36	1.04	107.06	0.879**	-20.258	1.96	1.04
BO 109	33.17	0.869	-1.381	0.01	1.12	100.04	0.158	-29.410	30.51	1.00	87.59	0.601**	-20.453	6.55	1.03
BO 110	32.11	0.992**	-1.327	0.30	1.15	114.36	0.226	-29.524	25.93	1.15	98.81	0.481**	-20.808	9.61	1.02
BO 130	27.83	1.350**	-1.350	2.98	1.25	93.21	2.125**	-23.537	63.98	1.01	81.29	1.582**	-19.090	15.51	1.11
BO 136	37.38	2.280**	-1.431	36.53	1.31	111.91	0.366	-28.740	19.83	1.10	101.08	0.307	-20.085	18.30	1.00
BO 137	28.56	0.925**	0.514	4.09	1.17	100.47	1.643**	30.151	17.24	1.09	87.12	1.273	-2.274	40.09	1.04
BO 139	26.79	1.331**	-0.614	4.16	1.26	85.47	1.317**	-30.445	4.58	1.07	78.22	1.087**	-19.742	2.77	1.08
BO 141	29.78	0.760**	-0.349	31.81	1.11	98.77	1.157**	-29.595	3.31	1.04	96.04	1.296**	-16.949	11.10	1.08
BO 144	30.22	0.743**	0.450	5.30	1.25	102.26	0.832**	-30.501	1.67	1.10	87.21	0.626**	-18.443	9.88	1.03
BO 145	32.43	0.580**	-1.324	4.23	1.08	101.71	1.502**	-26.510	18.37	1.06	91.47	1.258**	18.137	8.02	1.08
BO 146	30.60	0.284	6.235	26.77	1.05	122.83	1.328**	-30.603	4.54	1.05	98.32	0.753	6.402	56.94	1.00
BO 147	38.09	2.080**	-0.510	27.84	1.29	136.31	1.311**	-26.495	12.38	1.05	123.02	1.314**	-19.551	6.31	1.06
CoP 022	27.09	0.215	2.003	20.67	1.03	84.16	0.273	-28.942	24.40	1.00	74.79	1.431**	-16.572	15.26	1.12
CoP 9702	31.83	1.251**	3.915	4.46	1.19	94.87	1.242**	-28.143	7.56	1.08	98.16	1,100**	-20.840	0.66	1.06
Mean	31.25					105.11					92.69				
SEm±	0.99					5.54					4.554				

*Significant at p=0.05; ** at p=0.01

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Genotypes	Plant height (cm)					Cane yield (t ha^{-1})				
	X	bi	S^2di	Wi	S.F.	X	bi	S^2di	Wi	S.F.
BO 91	197.19	0.720**	-81.818	9.80	1.03	49.64	0.704**	-8.114	9.67	1.12
BO 99	182.79	0.305**	-82.006	56.24	1.01	63.96	1.966**	2.399	104.57	1.24
BO 109	245.70	1.300**	-81.368	12.09	1.05	64.65	0.756**	-9.119	5.25	1.09
BO 110	228.58	1.185**	81.948	4.45	1.05	62.29	0.443**	-7.290	30.72	1.07
BO 130	261.51	1.647**	-63.898	149.85	1.05	67.21	1.279**	-5.984	13.22	1.18
BO 136	248.10	0.983**	-74.430	7.56	1.04	73.82	0.620**	-8.627	13.60	1.06
BO 137	264.74	1.509**	-77.665	39.15	1.06	66.30	0.954**	-7.996	34.49	1.07
BO 139	283.46	1.910**	-77.902	104.55	1.07	69.49	0.963**	-8.331	1.79	1.12
BO 141	271.05	0.958**	-80.360	3.87	1.03	83.62	1.019**	-3.557	11.27	1.12
BO 144	229.54	0.887**	-81.547	2.76	1.03	63.07	0.637**	-7.992	13.78	1.08
BO 145	257.87	1.031**	-81.809	0.88	1.04	66.68	1.199**	-6.198	9.43	1.17
BO 146	284.65	0.503**	-81.832	29.29	1.01	84.61	0.897	7.517	34.24	1.04
BO 147	290.10	0.805**	-80.925	6.95	1.02	93.07	1.217	-5.430	11.58	1.12
CoP 022	259.72	0.801**	-81.324	6.30	1.02	53.88	1.139**	-8.380	3.29	1.18
CoP 9702	273.02	0.447**	-81.737	36.33	1.01	69.56	1.200**	-8.796	4.24	1.14
Mean	251.86					68.79				
SEm±	8.93					2.72				

Wi and S.F. indicates ecovalence and stability factor, respectively; *Significant at p=0.05; ** at p=0.01

while, for germination percent at 45 days after planting BO 99 recorded S.F. value nearest to unity followed by CoP 022, BO 146 and BO 145.

Wricke (1962) reported 'Wi' index of stability which represent proportion of genotype×environment sum of squares attributed by single genotype and the genotype which attributes minimum towards genotype×environment interaction component was supposed to be stable one (Table 2). The estimated ecovalence (Table 3) revealed that the genotypes, BO 139, CoP 022, CoP 9702 and BO 109 showed high mean for cane yield and exhibited low 'Wi' values which indicated that these genotypes had contributed minimum towards genotype×environment interaction component. Lowest Wi value for number of millable canes was estimated for the genotype CoP 9702 followed by BO 91, BO 99 and BO 139. Number of shoots at 120 days after planting recorded lowest Wi value for the genotype BO 144 followed by BO 141, BO 146 and BO 139. The genotype BO 99 followed by CoP 9702, BO 146 and BO 145 recorded lowest Wi value for germination percent at 45 days after planting. The above mentioned parametric methods for estimating the genotype×environment interaction and phenotypic stability have been widely used in plant breeding.

4. Conclusion

Wider adaptability was exhibited by the genotypes BO 146 and BO 147 for yield and yield attributing traits. These genotypes can be suggested for commercial cultivation in a wide range of environmental conditions and can be used further breeding programme.

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