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STABILITY ANALYSIS OF BRINJAL (*Solanum melongena*) HYBRIDS AND THEIR PARENTS FOR YIELD AND YIELD COMPONENTS

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SUMMARY

Thirty four brinjal genotypes were evaluated for yield and its components in 3 locations. Genotype x environment (G x E) interactions of both linear and non-linear were significant for all the characters under the study indicating that linear as well as non-linear components were important. Stable genotypes were identified for wider environments and specific environments with high per se performance (over general mean and check hybrids) for fruit yield per plant. It is evident from the information that 5 hybrids (Heera x Bhagyamathi, Heera x Gulabi, Heera x Shyamala, Pusa Shyamala x Gulabi and IC 285140 x Bhagyamathi) were found stable and widely adapted with high mean performance, average responsiveness ($b_i \approx 1$) for fruit yield per plant and could be utilized for variable environments. A perusal of the results on environmental index for various traits under different environments also suggested variable response of the seasons to the different traits studied. Venkataramannagudem was observed to be most ideal location for fruit yield per plant.

Key words: Stability analysis, G x E interaction, brinjal

Key findings: Linear as well as nonlinear components of genotype x environment interaction played an important role in the expression of all the characters and suggested that environments used in the study differed in several physical parameters resulting in the differential response of genotypes to different environmental conditions. Significant deviation from regression may arise due to specific environmental interaction. The potential stable genotypes may use in breeding programmes for incorporation of stability for yield and other characters.

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INTRODUCTION

Brinjal *(Solanum melongena* L.) is a major solanaceous fruit vegetable with chromosome number 2n = 24. It is grown extensively throughout the country, in almost all the states. It is a good source of nutrients. It contains 122 IU of vitamin A, 12 mg of vitamin C, 18 mg of calcium, 47 mg of phosphorous, 0.9 mg of iron, 1.4 g of protein, 4 g of carbohydrates per 100 g

of fresh weight (Thamburaj and Singh, 2004). Nutritive value of brinjal is well compared with tomato (Choudhary, 1976). They are also known to have alkaloid solanine in roots and leaves. Some medicinal uses of brinjal include treatment of diabetes, asthma, cholera and bronchitis. Fruits and leaves are administered to lower blood cholesterol levels.

Phenotypically stable genotypes (varieties/hybrids) are of great importance, because environmental condition varies from season to season. Wide adaptation to a particular environment and consistent performance of recommended genotypes is one of the main objectives in breeding programme. Brinjal is grown round the year and is highly influenced by varied agro-climatic conditions (Chadha and Singh, 1982). Therefore, it is necessary to develop varieties or hybrids having stable performance across environments. Precise knowledge on the nature and magnitude of genotype x environment interactions is important in understanding the stability in yield of a particular variety or hybrid before it is being recommended for a given situation. Testing of genotype under different environments differing in unpredictable variation is an accepted approach for selecting stable genotypes (Eberhart and Russel, 1966). In order to identify stable genotypes, the genotype by environment interactions must be partitioned into stability statistics that are assignable to each genotype evaluated across a range of environments. Stability indices have allowed researchers to identify widely adapted genotypes for use in breeding programs.

MATERIAL AND METHODS

The experimental material comprised of 7 lines (IC 090053, IC 285140, IC 421194, IC 545893, IC 90806, Pusa Shyamala and Heera), 3 testers (Bhagyamathi, Gulabi and Shyamala) and the resulting 21 F1 hybrids generated by crossing the 7 lines and 3 testers in line × tester mating design during *kharif* season 2013. All these parents were selected based on the genetic divergence study. The resulting hybrids along with 10 parents and 3 hybrid checks *viz*., Ravaiyya, Kanaka Durga and US 172 were evaluated in a Randomized Complete Block Design with 3 replications for their stability during summer, 2014 at 3 different locations, *viz*., Horticultural College and Research Institute, Venkataramannagudem (VRG); Horticultural Research Station, Pandirimamidi (PMD), East Godavari and Horticultural Research Station, Aswaraopet (ASPT), Khammam. All the entries at the age of 30 days were transplanted in randomized complete block design with 3 replications. The plot size wasmaintained 4.5 x 3.75 m accommodating 25 plants in each plot at a distance of 90 x 75 cm from row to row and plants to plants and all recommended package of practices were followed to raise a healthy crop. Observations were recorded on plant height, days to flowering, number of fruits per cluster, fruit length, fruit girth, average fruit weight, number of fruits per plant and fruit yield from 5 randomly selected plants from each entry in each replication. Stability analysis was done as per the method suggested by Eberhart and Russell (1966) for yield and its components.

RESULTS

The analysis of variance (Table 1) revealed that the genotypes, environments and interaction between the genotype and environment (G x E) were significant for all the characters indicating the diversity among the genotypes, environments and G x E studied. The partitioning of environments + (genotypes x environments) mean squares (Table 1) showed that environments (linear) differed significantly and were quite diverse with regards to their effect on the performance of the genotypes for fruit yield and majority of yield components.

A perusal of the results on environmental index for various traits under different environments (Table 2) indicated Venkataramannagudem was observed to be favourable environment for fruit yield per plant, plant height average fruit weight, number of fruits per cluster and number of fruits per plant, while Pandirimamidi was observed to be ideal for days to flowering, number of fruits per cluster, fruit length, fruit girth and average fruit weight.

Table 1. Analysis of variance for yield and yield components for stability in brinjal.

Source	Df	Plant height (cm)	Days to flowering	No. of fruits per cluster	Fruit length (cm)	Fruit girth (cm)	Average fruit weight (g)	No. of fruits/plant	Fruit yield/plant (kg)
Varieties	33	313.69**	18.85**	0.36**	24.90**	13.97**	731.71**	1227.36**	2.54**
Env + (Var * Env)	68	42.47**	38.85**	0.02**	0.74**	0.38**	8.42**	79.31**	0.18**
Environments	2	1425.13**	1070.01**	0.16**	7.65**	0.54*	88.34**	1604.19**	2.00**
Var * Env	66	0.57**	7.61*	0.02**	0.61*	0.37**	5.99*	33.10*	0.13**
Environments(Lin)	1	2850.26**	2140.03**	0.62**	14.23**	1.07*	176.68**	3208.32**	6.98**
Var * Env (Lin)	33	1.09**	10.77**	0.02*	0.84**	0.58**	8.38**	47.14**	0.11**
Pooled Deviation	34	0.05**	4.31**	0.01	0.31**	0.16**	3.51	18.49	0.05
Pooled Error	198	8.69**	1.02	0.01	0.07	0.05	2.52	26.06	0.07

*: Significant at 5% level; **: Significant at 1% level

Table 2. Environmental indices for yield and yield components in brinjal.

Characters	Locations		
	VRG	PMD	ASPT
Plant height	7.292	-5.073	-2.219
Days to 50 % flowering	5.961	-5.176	-0.784
Number of fruits per cluster	0.034	0.075	-0.108
Fruit length	-0.172	0.702	-0.530
Fruit girth	-0.141	0.099	0.042
Average fruit weight	-0.305	1.742	-1.438
Number of fruits per plant	7.662	-2.056	-5.606
Fruit yield per plant	0.356	-0.091	-0.265

VRG = Venkataramannagudem; PMD = Pandirimamidi; ASPT = Aswaraopet

To assess the stability of genotype regression coefficient (b_i) is considered as a parameter of response of a particular genotype and deviation from regression (S^2d_i) as a parameter of stability. Hence, the mean performance of genotypes, along with regression coefficient (b_i) and deviation from regression (S^2d_i) were estimated and are presented in Tables 3, 4 and 5. The genotypes with regression coefficient (b_i) near to unity (1) and non-significant deviation from regression (S^2d_i) were considered as stable genotypes as their performance can be predicated over the environment. It is evident from the information that among the parents Pusa Shyamala, Heera, IC 285140, Gulabi and Bhagyamathi were found high yielders, stable and adaptable to wider environments with average responsiveness ($b_i \approx 1$). These parents were also stable for other yield contributing traits and these genotypes can be used in breeding programmes to incorporate stability for fruit yield.

Among hybrids, Heera x Bhagyamathi (5.15 kg), Heera x Gulabi (5.11 kg), Heera x Shyamala (4.98 kg), IC 285140 x Bhagyamathi (4.23 kg), Pusa Shyamala x Gulabi (4.74 kg), IC 421194 x Gulabi (4.04 kg) and IC 421194 x Bhagyamathi (3.82 kg) hybrids registered more yield per plant than the checks. IC 421194 x Bhagyamathi exhibited more than one bi value, hence is adaptable to favorable environments with less than average stability. Heera x Bhagyamathi exhibited less than one bi value, hence is adaptable to poor environments with more than average stability.

Considering the overall performance of all hybrids for *per se* performance and stability 5 hybrids *viz*., Heera x Bhagyamathi, Heera x Gulabi, Heera x Shyamala, Pusa Shyamala x Gulabi and IC 285140 x Bhagyamathi were found promising with high yield and stable

performance for number of characters (Table 6). These hybrids can be recommended for general cultivation and can also be utilized in breeding programme to incorporate stability for fruit yield and other important traits.

Table 3. Mean performance and stability parameters for plant height and days to flowering in brinjal.

Parent/Hybrid	Plant height (cm)			Days to 50% flowering		
	Mean	b_i	S^2d_i	Mean	B_i	S^2d_i
IC 090053	128.20	1.11	-8.59	41.44	0.23	-0.80
IC 285140	143.00	0.87	-8.57	45.00	1.27	5.09*
IC 421194	143.50	0.79	-8.44	46.78	1.22	8.41**
IC 545893	104.60	1.01	-8.64	48.67	0.79	0.34
IC 90806	143.80	0.94	-8.63	45.00	-0.33	55.20**
Pusa Shyamala	118.40	1.16	-8.53	44.22	1.55	12.69**
Heera	120.70	0.87	-8.57	48.44	1.07	1.41
Bhagyamathi	127.80	0.88	-8.58	46.22	0.50	6.11**
Gulabi	142.70	0.90	-8.60	46.56	1.16	-0.85
Shyamala	125.60	1.04	-8.63	41.89	1.40	0.89
IC 090053 x Bhagyamathi	132.80	1.01	-8.64	43.78	0.69	-0.96
IC 090053 x Gulabi	135.40	0.88	-8.58	39.11	1.44	3.10*
IC 090053 x Shyamala	131.80	1.15	-8.54	47.11	1.03	-0.30
IC 285140 x Bhagyamathi	134.80	1.00	-8.64	39.44	1.42	5.06*
IC 285140 x Gulabi	137.20	0.90	-8.60	44.67	1.04	-0.69
IC 285140 x Shyamala	141.70	0.78	-8.43	43.22	0.90	-0.99
IC 421194 x Bhagyamathi	126.00	1.12	-8.58	45.44	0.74	5.89*
IC 421194 x Gulabi	144.00	0.97	-8.64	44.67	1.12	-0.10
IC 421194 x Shyamala	141.00	0.99	-8.64	45.33	1.10	0.93
IC 545893 x Bhagyamathi	137.60	1.13	-8.57	44.78	1.00	0.50
IC 545893 x Gulabi	128.50	1.10	-8.60	42.22	1.17	-0.90
IC 545893 x Shyamala	128.70	1.01	-8.64	40.11	1.42	-0.36
IC 90806 x Bhagyamathi	133.90	1.00	-8.64	42.00	1.05	-1.00
IC 90806 x Gulabi	136.50	0.98	-8.64	42.56	1.20	2.93
IC 90806 x Shyamala	143.90	1.15	-8.54	41.11	1.25	0.91
Pusa Shyamala x Bhagyamathi	104.40	1.20	-8.47	42.56	0.96	-1.02
Pusa Shyamala x Gulabi	128.90	0.93	-8.62	43.11	1.39	-0.32
Pusa Shyamala x Shyamala	135.50	1.04	-8.63	43.67	1.19	-0.93
Heera x Bhagyamathi	115.40	1.16	-8.54	44.33	0.83	-0.41
Heera x Gulabi	129.00	0.87	-8.56	44.56	1.10	1.76
Heera x Shyamala	121.60	1.09	-8.61	41.22	0.81	3.58*
Ravaiyya	126.50	1.11	-8.59	41.89	1.61	-0.83
Kanaka Durga	127.90	0.90	-8.60	41.56	0.26	4.94*
US 172	131.90	0.99	-8.64	39.00	0.42	1.66
SE of b_i		0.00			0.26	

*: Significant at 5% level; **: Significant at 1% level

Table 4. Mean performance and stability parameters for number of fruits per cluster, fruit length and fruit girth in brinjal.

Parent/Hybrid	No. of fruits per cluster			Fruit length (cm)			Fruit girth (cm)		
	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
IC 090053	2.39	0.86	-0.01	9.06	-0.88*	-0.05	13.31	5.23	-0.05
IC 285140	2.98	0.54	0.00	8.46	1.58	0.04	12.48	-0.39	0.16
IC 421194	2.33	1.32	0.00	11.22	0.33	0.50**	13.87	2.86	-0.03
IC 545893	2.11	0.90	0.00	7.10	0.63	-0.07	16.78	4.17	0.00
IC 90806	1.78	-0.63	0.01	10.16	1.67	1.48**	15.85	8.89	-0.04
Pusa Shyamala	2.40	2.64	0.00	15.81	1.80	0.13	13.06	1.38	-0.05
Heera	2.34	1.79	0.00	15.55	-0.15	0.04	16.21	2.27	0.00
Bhagyamathi	2.74	1.49	0.00	8.56	1.00	0.18	14.83	-1.51	0.01
Gulabi	2.39	2.03	-0.01	15.06	0.53	0.17	12.36	1.32	-0.02
Shyamala	2.32	0.86	-0.01	7.68	0.54	-0.03	14.87	7.22	0.28*
IC 090053 x Bhagyamathi	2.53	0.99	-0.01	8.13	0.56	0.09	14.02	2.49	-0.04
IC 090053 x Gulabi	2.41	0.47	-0.01	10.32	1.00	0.15	12.67	10.40**	-0.05
IC 090053 x Shyamala	2.39	0.89	0.01	8.05	1.12	-0.06	15.38	-6.68**	-0.05
IC 285140 x Bhagyamathi	3.11	-0.27	-0.01	7.75	1.10	-0.02	13.25	0.98	-0.05
IC 285140 x Gulabi	2.86	-0.47	-0.01	12.74	0.99	-0.06	10.99	-1.86	0.07
IC 285140 x Shyamala	2.50	1.61	0.01	9.31	0.97	-0.04	15.08	3.74	1.20**
IC 421194 x Bhagyamathi	3.26	0.05	0.00	9.40	0.88	0.72**	14.09	-7.38	0.09
IC 421194 x Gulabi	2.81	0.17	0.01	11.59	1.32	0.49**	12.19	4.13	0.26*
IC 421194 x Shyamala	2.52	1.70	-0.01	8.06	1.20	0.31*	16.58	-3.28*	-0.05
IC 545893 x Bhagyamathi	2.52	1.67	0.01	9.13	-0.07	1.57**	16.40	-0.33	0.08
IC 545893 x Gulabi	2.84	1.56	-0.01	10.30	1.02	0.53**	16.90	1.40	-0.03
IC 545893 x Shyamala	2.60	1.98	0.00	8.14	0.97	0.40**	17.18	3.00	0.11
IC 90806 x Bhagyamathi	3.10	0.59	-0.01	10.36	0.57	0.01	16.68	-4.75**	-0.05
IC 90806 x Gulabi	2.32	1.52	-0.01	12.79	2.36	0.52**	13.84	-9.42	1.00**
IC 90806 x Shyamala	2.42	0.78	-0.01	10.40	0.69	0.17	18.97	-0.03	0.00
Pusa Shyamala x Bhagyamathi	2.42	1.44	-0.01	16.39	2.24*	-0.06	12.25	3.94**	-0.05
Pusa Shyamala x Gulabi	3.41	-0.82	0.03*	14.90	0.28	0.02	11.26	1.92	-0.01
Pusa Shyamala x Shyamala	2.46	2.69*	-0.01	9.66	1.42	0.08	14.99	5.86	0.23*
Heera x Bhagyamathi	2.80	2.49	-0.01	13.25	0.84	0.32*	15.29	0.13	-0.04
Heera x Gulabi	2.73	0.15	0.00	14.60	1.51	0.01	14.14	-0.18	0.25*
Heera x Shyamala	2.33	1.83*	-0.01	11.56	0.98	-0.04	16.80	-1.02	0.49**
Ravaiyya	2.94	-0.05	0.00	7.29	0.96	0.12	18.24	-1.80*	-0.05
Kanaka Durga	2.98	0.90	0.00	15.64	2.26	0.63**	10.80	1.29	-0.03
US 172	2.99	0.34	0.00	14.01	1.81**	-0.07	11.12	0.01	0.11
SE of b_i		0.62			0.62			2.26	

*: Significant at 5% level; **: Significant at 1% level

Table 5. Mean performance and stability parameters for average fruit weight, number of fruits per plant and yield per plant in brinjal.

Parent/hybrid	Average fruit weight (g)			Number of fruits per plant			Yield/plant (kg)		
	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
IC 090053	78.55	-0.67	2.59	30.38	0.08	-22.78	1.93	0.74	-0.06
IC 285140	46.91	-0.48	-0.46	90.05	1.04	39.44	3.04	0.81	-0.02
IC 421194	83.04	-0.74*	-2.50	35.78	0.58*	-26.69	2.31	0.94	-0.07
IC 545893	89.78	1.18	-2.15	31.76	0.08	-21.16	1.72	-0.05	0.01
IC 90806	92.06	1.92	-2.47	39.62	0.36	-20.55	2.48	0.28	-0.04
Pusa Shyamala	93.84	2.28	1.79	60.97	0.56	-24.12	4.12	0.94	-0.03
Heera	102.99	-0.29	-2.41	46.06	0.83	-26.20	3.40	1.16	-0.07
Bhagyamathi	63.29	-1.15	-0.31	50.25	0.49	-17.57	2.48	0.33	-0.04
Gulabi	70.44	-0.58	-0.36	56.97	0.96	-26.71	2.93	0.82	-0.07
Shyamala	67.89	3.21	-1.25	36.94	-0.02	9.28	1.84	-0.15	0.03
IC 090053 x Bhagyamathi	53.69	-0.02	-0.99	62.35	1.46	-4.52	2.86	1.55	-0.07
IC 090053 x Gulabi	62.88	2.55	15.20**	56.13	1.16	13.42	2.87	1.23	-0.06
IC 090053 x Shyamala	57.39	0.42	-2.35	50.45	1.09	-24.13	2.25	0.85	-0.05
IC 285140 x Bhagyamathi	48.72	0.57	-1.93	113.75	1.34	-26.63	4.23	0.65	0.01
IC 285140 x Gulabi	52.24	1.06	6.36	63.56	0.55	-4.72	2.59	0.31	-0.01
IC 285140 x Shyamala	63.75	2.60	-2.09	75.82	1.73	-11.04	3.52	1.69	0.02
IC 421194 x Bhagyamathi	59.56	1.52	9.58*	91.15	2.79*	-26.62	3.82	2.68*	-0.07
IC 421194 x Gulabi	66.86	2.37	-0.44	88.95	1.77	-10.92	4.04	1.55	-0.04
IC 421194 x Shyamala	77.83	1.25	-1.59	69.38	0.18	3.36	3.00	0.90	-0.01
IC 545893 x Bhagyamathi	76.60	-0.60	5.87	57.33	-0.24	14.69	2.78	-0.20	0.07
IC 545893 x Gulabi	87.42	3.38	13.73*	65.97	1.46	-3.01	3.01	1.36	-0.06
IC 545893 x Shyamala	83.90	3.09	-0.82	43.43	0.13	-1.97	2.91	0.38	-0.01
IC 90806 x Bhagyamathi	93.32	0.15	-2.16	60.52	1.39	-13.16	3.86	1.91	0.05
IC 90806 x Gulabi	74.73	-0.45	-1.68	78.87	2.08	-0.14	3.97	1.90	-0.03
IC 90806 x Shyamala	95.99	1.22	-0.67	46.69	0.84	-26.50	3.04	0.83	-0.06
Pusa Shyamala x Bhagyamathi	91.53	2.16	-0.46	47.99	1.23	-11.10	3.11	1.59	-0.01
Pusa Shyamala x Gulabi	69.91	1.65	-1.76	97.88	1.74	-21.52	4.74	1.33	-0.06
Pusa Shyamala x Shyamala	76.51	1.72	-2.13	72.22	1.48	-16.19	3.80	1.43	-0.06
Heera x Bhagyamathi	90.53	0.91	-2.41	88.17	1.37	4.58	5.15	-1.26*	0.09
Heera x Gulabi	88.23	0.79	2.84	71.47	1.38	-26.63	4.98	2.29	-0.06
Heera x Shyamala	102.92	1.42	-2.30	69.31	1.18	-25.47	5.11	1.87	-0.04
Ravaiyya	92.30	1.28	9.54*	43.51	0.41	40.46	2.68	0.58	0.12
Kanaka Durga	73.78	0.77	3.67	53.92	0.35	12.76	2.51	0.85	0.05
US 172	69.77	-0.47	-1.45	75.22	2.16	22.26	3.80	1.91	0.00
SE of b_i		0.82			0.44			0.49	

*: Significant at 5% level; **: Significant at 1% level

Table 6. Most promising hybrids identified in the investigation.

	Hybrid				
	Heera x Bhagyamathi	Heera x Shyamala	Heera x Gulabi	Pusa Shyamala x Gulabi	IC 285140 x Bhagyamathi
Stability	Plant height, Days to 50% flowering, Days to first harvest, No. of fruits per cluster, Fruit girth, Average fruit weight, Number of fruits per plant, Yield/plant	Plant height, Days to first harvest, No. of fruits per cluster, Fruit length, Average fruit weight, Number of fruits per plant, Yield/plant	Plant height, Days to 50% flowering, Days to first harvest, No. of fruits per cluster, Fruit length, Average fruit weight, Number of fruits per plant, Yield/plant	Plant height, Days to 50% flowering, Fruit length, Fruit girth, Average fruit weight, Number of fruits per plant, Yield/plant	Plant height, No. of fruits per cluster, Fruit length, Fruit girth, Average fruit weight, Number of fruits per plant, Yield/plant

DISCUSSION

Higher magnitude of mean squares due to the genotype and environments indicated considerable differences between genotype and environments for all the characters and that these characters were influenced greatly by genotype and environments thereby suggesting that large differences between genotypes and environments along with the greater part of genotypic response was a linear function of environments *i.e.* the environments created by sowing over locations was justified and had linear effects. These results are consistent with the earlier findings of Prasad *et al*. (2002) and Vaddoria *et al*. (2009).Significant variability due to genotype environment interactions (G × E) for all the characters indicated the differential response of genotypes across the environments for the traits. Similar observations were recorded by Lila *et al.* (2011) for fruit yield and other characters. Variance of genotype x environment (linear) when tested against pooled deviation was significant indicated that the genotypes were diverse in their regression response with environmental fluctuations. Vaddoria *et al*. (2009) also found significance of genotype x environment (linear) for fruit yield and other important traits.

Singh *et al*. (1988) had suggested the utilization of stable and potential genotypes in breeding programmes for incorporation of stability. From a breeding point of view, the parents Pusa Shyamala, Heera, IC 285140, Gulabi and Bhagyamathi were observed to be stable genotypes for fruit yield and some of the yield attributes.

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