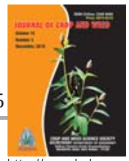
*Journal of Crop and Weed, 15(3): 79-86 (2019)*

ISSN- O : 2349 9400 ; P : 0974 6315



http://cwssbckv.org
www.cropandweed.com

# Phenotypic stability in brinjal genotypes

**[1]S. AKHTAR, AAKANKSHA, R. KUMARI,**
**[1]S. S. SOLANKEY AND [2]D.K. BARANWAL**

*[1]Department of Horticulture (Vegetable and Floriculture), Department of Plant Breeding and Genetics*
*Bihar Agricultural University, Sabour, Bhagalpur, Bihar -813210, India*
*[2]Plant Breeding Institute, University of Sydney, NSW 2570, Australia*

*Received : 10.11.2019 ; Revised : 20.12.2019 ; Accepted : 25.12.2019*
**DOI:** https://dx.doi.org/10.22271/09746315.2019.v15.i3.1241

**ABSTRACT**

*Brinjal is a popular day neutral vegetable crop, but it is somewhat thermosensitive. A temperature regime of 18 to 25 °C with warm climate is desirable for successful brinjal production. Both higher and lower temperatures severely hamper fruitset. Therefore, the performance of brinjal varieties varies throughout the different seasons in a year and also in different years. Hence, breeders aim at developing stable varieties. Our objectives were to observe the genotype × environment interaction on brinjal genotypes, estimate phenotypic stability of yield attributes and identification of genotype(s) with stable performance. Twenty diverse genotypes were grown in three environments, namely, autumn-winter, 2013- '14, summer-rainy, 2014 and early autumn-winter, 2015- '16 in randomized block design replicated thrice. Analysis of variance depicted significant variation in the genotypes in addition to the environments. Significant G × E interaction were noted for fruit numberplant$^{-1}$, average weight, length and girth of fruit and also plant height which also indicated the significance of both linear as well as non-linear components. The stable genotypes were different for different traits, viz., Rajendra Baingan-2 and IIHR 562 (plant height), IC 261802, Arka Neelkanth, Pusa Purple Cluster (plant spread), Brinjal 71-19 (days to 50% flowering), BRBR-01 and IC-261802 (days to first harvest), Punjab Brinjal-67, BRBL-04, Pusa Purple Cluster (fruit length), IC 261802, IC 89933, BRBL-01 (fruit girth), Pant Rituraj and BRBL-01 (number of fruits/plant), and BRBL-01, BRBL-04 and Punjab Brinjal-67 (for yield per plant and total yield). From this investigation BRBL-01, BRBL-04 and Punjab Brinjal-67 were identified as the most promising stable genotypes, and these could be cultivated throughout the year and also used in breeding programmes for developing stable varieties.*

***Keywords***: Agronomic traits, brinjal, G × E interaction, stability.

One of the most popular crops of the world, brinjal (*Solanum melongena* L.) also called eggplant in the UK due to its small white egg shaped fruits, and aubergine in the United States, and is one of the foremost important vegetable crop of India also, grown in diverse climatic zones of the country except higher altitudes. India has a rich diversity of the crop, being the origin place of the crop besides being the second largest brinjal producing country with an area of 0.73 million ha, production of 12.801 million tonnes and productivity of 17.5 metric tonnes ha$^{-1}$, respectively (Anonymous, 2018). The crop requires a long and warm growing season with range of cardinal temperature 18 to 21 °C for a good yield (Nath *et al*., 2008). Despite being cultivated throughout the year in most parts of India, the available varieties produce poor yield in summer the chief reason being the prevailing high temperature, often coupled with with strong wind, which has adverse effect on fruitset (Singh and Kalda, 2000). Lower temperatures are equally detrimental to fruitset. The performance of the same variety shows marked difference when cultivated during summer and autumn-winter season (Pandit *et al*., 2010). Most of the available brinjal varieties of India are unable to deliver their potential performance due to the environmental shock. The real performance of any cultivar is controlled by its genetic constitution (genotype), available environment and interaction between genotype and environment. It is extremely hard to manage environmental conditions so researchers target to reduce the effects of its interaction with genotype (Basford and Cooper, 1998). It seems easier because some of the available genetic stock show minimum genotype-environment interaction (G × E). Genotype × environment (G×E) interaction is essential criteria to judge the adaptability of existing varieties and advance breeding lines. The occurrence of G×E interaction shrinks the association between phenotypic expression and the genotype, and hence the genetic potential is often misjudged that changes the relative ranking of the genotypes in changing environments (Kang, 1990). To achieve stable varieties, recent breeding programmes focus to minimise the contribution of G × E interaction. In this reference, evaluation of varietal trials is being carried out at different locations to create a wide range of environments to identify high yielding stable varieties. Even though for same location, phenotypically stable genotypes are of great importance due to fluctuations in environmental conditions from year to year or season to season. The model of Eberhart and Russell (1966) to estimate stability of any genotype is based on two parameters, *viz*., the slope of the regression line and the sum of squared deviations from regression. Unit regression ($b_i = 1$) and least deviation from linearity of regression slope ( $S_d^2 = 0$) yielded a stable genotype. Considering the importance of above approaches and this model, a study has been carried out to screen out

*Email : shirin.0410@gmail.com*

phenotypically stable brinjal varieties for different seasons.

## MATERIALS AND METHODS

The field experiment was conducted with twenty diverse brinjal genotypes at Vegetable Research Farm, Bihar Agricultural University, Sabour, Bhagalpur , Bihar in the heart of eastern Indo-Gangetic plains, having extremely hot and dry summer, severely chilly winter and moderate precipitation. Twenty genotypes of brinjal including popular varieties, breeding lines, indigenous collections collected from different institutes or developed and maintained at Bihar Agricultural University, Sabour were planted in three seasons, i.e., autumn-winter, 2013-'14, summer-rainy, 2014 and early autumn-winter, 2015-'16 in randomised block design replicated thrice. For autumn-winter 2013-'14, seeds were sown in mid August and transplanted in mid September of 2013. For summer-rainy season, 2014 seeds were sown in March and transplanting was carried out in April, 2014, while for early autumn-winter, 2015-'16 season, sowing was done in first week of July and transplanting in first week of August, 2015. A spacing of 60 x 60 cm was maintained and standardised agro-techniques to raise a good crop were followed. For data recording, five randomly selected plants per plot leaving out the border ones in each replication were tagged and numbered. Observations were recorded for a number of traits however, only twelve key agronomic traits were considered for this study.

Analysis of variance for randomised block design of the recorded data was carried out as per the method of Panse and Sukhatme (1967). The analysis of stability parameters was estimated as per Eberhart and Russell model (1966), which used three parameters, *viz*., mean, linear regression and mean square deviation from linear regression to define the stability of genotypes. Pooled analysis of variance for stability model was carried out by using means for different traits of the genotypes under different environments according to Fisher (1946).

## RESULTS AND DISCUSSION

Analysis of variance for the traits in each season revealed ample variation among the genotypes in each season for every character excepting primary branch number per plant. These imply genetic difference among the twenty genotypes and there was sufficient scope to select promising stable genotypes (Mohanty, 2001). Pooled ANOVA for stability model (Table 1) showed that the variance for environment were significant for every trait. This justified necessity of carrying out the investigation since environment exerted influence on the performance of the genotypes. However, genotype × environment was significant every characters under study apart from primary branch number per plant. This was indicative of sufficient interaction among the genotypes and environment affecting phenotypic expression. The variance due to linear component of environment was significant for all the attributes under study that point out to additivity of the environmental effects. The significant variance due to environment plus genotype x environment interaction denoted that the environmental condition of different seasons and years and the genotypes considerably interacted. These findings find accordance with Sivakumar *et al*. (2015), Bora *et al*. (2011), Suneetha *et al*. (2006), Krishna Prasad *et al*. (2002), Mohanty and Prusti (2000), Srivastva *et al*. (1997), Vadivel and Bapu (1989), Yusufzai (1989), Sidhu (1989) and Singh *et al*. (1985). The linear components of genotype × environment interaction were found to be highly significant for all the traits except number of fruit length, fruit girth and number of primary branches per plant. Significant pooled deviation was observed for all characters with exception of primary branch number per plant and fruit number per plant pointed out at the contribution of digression from linear regression towards the variation in the stability of genotype (Krishna Prasad et al., 2002) and indicative of predominance of non-linear component of G × E interaction (Rai *et al*., 2000 and Chaurasia *et al*., 2005).

The season of growing the twenty genotypes, demarcated by the different dates of transplanting them, had overwhelming influence on most of the characters, while on few characters like primary branch number per plant, it was least. Ratnavathi *et al*. (2005) and Revanappa and Kajjidoni (2004) also reported effect of growing season on phenotypic expression. In summer-rainy season, the mean values for all the growth and yield attributes were low, while 50% flowering and first harvesting were delayed. Besides, this season also recorded the lowest environmental index for all traits (Table 2), thus indicative of the most unfavoured time of brinjal growing. The environmental index was found to be maximum, for most yield and its attributing traits, in autumn-winter season, suggesting that this season with August transplanting is most suited for brinjal cultivation. Primary branch number per plant seemed not impacted by the environment. Earlier reports of Vadodaria et al. (2009) are comparable with our findings.

According to the mathematical model of stability by Eberhart and Russell (1966), the genotype × environment interaction of any genotype has been partitioned into two parts, *i.e.*, slope of the regression line and deviation from it. A genotype was considered stable when having regression coefficient was unity ($b_i = 1$) and there was least deviation from regression line ($S_d^2 = 0$), and it was supposed to be suited for all conditions, and referred to as average responsive. However, the mean value was also taken into account and the genotype should possess desirable mean value also. Any genotype with $b_i > 1$ was considered highly responsive, *i.e.*, suitable for favourable environment, whereas those possessing $b_i < 1$ was called low responsive, *i.e.*, suitable for unfavourable situations. High and desirable *per se*

**Table 1: Analysis of variance with respect to 12 quantitative characters over 3 environments in 20 brinjal genotypes**

| Source of variation | Degrees of freedom | Mean sum of squares | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant height (cm) | | | Plant spead (cm) | | | Number of primary branches plant$^{-1}$ | | |
| | | $E_1$ | $E_2$ | $E_3$ | $E_1$ | $E_2$ | $E_3$ | $E_1$ | $E_2$ | $E_3$ |
| Genotypes | 19 | 435.06** | 163.37** | 405.58** | 282.46** | 148.4** | 353.83** | 2.43** | 0.34* | 0.3 |
| Replication | 2 | 32.34 | 17.635 | 39.29 | 26.77 | 14.90 | 0.93 | 0.15 | 0.11 | 0.8* |
| Error | 38 | 18.48 | 9.759 | 56.63 | 11.17 | 10.70 | 50.30 | 0.05 | 0.04 | 0.2 |
| **SE m( ±)** | **2.48** | **1.80** | **4.34** | **1.93** | **1.89** | **4.09** | **0.13** | **0.11** | **0.27** | |
| **LSD(0.05)** | **7.10** | **5.16** | **12.44** | **5.52** | **5.40** | **11.72** | **0.38** | **0.33** | **0.77** | |
| **LSD(0.01)** | **9.52** | **6.91** | **16.66** | **7.40** | **7.23** | **15.70** | **0.51** | **0.44** | **1.03** | |
| | | Days to first flowering | | | Days to 50 % flowering | | | Days to first harvest | | |
| | | $E_1$ | $E_2$ | $E_3$ | $E_1$ | $E_2$ | $E_3$ | $E_1$ | $E_2$ | $E_3$ |
| Genotypes | 19 | 95.63** | 59.49** | 74.49** | 73.27** | 42.66** | 45.94** | 93.27** | 85.78** | 83.39** |
| Replication | 2 | 7.82 | 3.32 | 23.45 | 1.55 | 0.45 | 0.65 | 17.52 | 7.55 | 25.32 |
| Error | 38 | 4.17 | 2.74 | 2.38 | 7.57 | 4.40 | 3.09 | 9.39 | 7.09 | 6.26 |
| **SE m( ±)** | **1.18** | **0.96** | **0.89** | **1.59** | **1.21** | **1.01** | **1.77** | **1.54** | **1.44** | |
| **LSD(0.05)** | **3.37** | **2.73** | **2.55** | **4.55** | **3.47** | **2.90** | **5.07** | **4.40** | **4.14** | |
| **LSD(0.01)** | **4.52** | **3.66** | **3.42** | **6.09** | **4.64** | **3.89** | **6.79** | **5.90** | **5.54** | |
| | | Fruit length (cm) | | | Fruit girth (cm) | | | Average fruit weight (g) | | |
| | | $E_1$ | $E_2$ | $E_3$ | $E_1$ | $E_2$ | $E_3$ | $E_1$ | $E_2$ | $E_3$ |
| Genotypes | 19 | 79.90** | 31.07** | 36.24** | 59.14** | 26.41** | 45.08** | 8323.51** | 772.37** | 4862.96** |
| Replication | 2 | 2.31 | 0.77 | 5.54 | 1.72 | 1.71 | 8.73 | 71.87 | 3.60 | 185.20 |
| Error | 38 | 1.26 | 0.29 | 1.80 | 0.79 | 0.85 | 4.75 | 77.74 | 13.83 | 276.41 |
| **SE m( ±)** | **0.65** | **0.31** | **0.78** | **0.51** | **0.53** | **1.26** | **5.09** | **2.15** | **9.60** | |
| **LSD(0.05)** | **1.86** | **0.88** | **2.22** | **1.47** | **1.52** | **3.60** | **14.57** | **6.15** | **27.48** | |
| **LSD(0.01)** | **2.49** | **1.18** | **2.97** | **1.97** | **2.04** | **4.83** | **19.52** | **8.24** | **36.81** | |
| | | Number of fruits per plant | | | Fruit yield plant$^{-1}$ (g) | | | Total yield (q ha$^{-1}$) | | |
| | | $E_1$ | $E_2$ | $E_3$ | $E_1$ | $E_2$ | $E_3$ | $E_1$ | $E_2$ | $E_3$ |
| Genotypes | 19 | 85.25** | 53.87** | 111.56** | 306757.97** | 123254.05** | 171202.26** | 23669.60** | 9510.34** | 13210.05** |
| Replication | 2 | 0.15 | 1.50 | 9.18 | 6963.61 | 937.20 | 29842.29 | 537.32 | 72.31 | 2302.65 |
| Error | 38 | 1.02 | 0.75 | 5.06 | 27212.04 | 1967.44 | 39326.26 | 2099.69 | 151.81 | 3034.43 |
| **SE m( ±)** | **0.58** | **0.50** | **1.30** | **95.24** | **25.61** | **114.49** | **26.46** | **7.11** | **31.80** | |
| **LSD(0.05)** | **1.67** | **1.43** | **3.72** | **272.61** | **73.30** | **327.72** | **75.73** | **20.36** | **91.03** | |
| **LSD(0.01)** | **2.24** | **1.92** | **4.98** | **365.28** | **98.22** | **439.12** | **101.47** | **27.28** | **121.98** | |

** and ** depict significance at 5% and 1% levels of probability respectively; $E_1$ = autumn-winter 2013-14 (September 2013 transplanting); $E_2$ = spring-summer 2014-15 (April 2014 transplanting); $E_3$ = early autumn-winter 2015-16 (August 2015 transplanting)*

**Table 2: Mean sum of squares for stability of twelve agronomic characters in 20 genotypes (Eberhart and Russel Model, 1966)**

| Sources of variation | | Mean Squares | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DF | PH | PS | NPB | DFF | D50F | DFH | FrL | FrG | FrP | AFrW | FYPP | Yield |
| Genotype | 19 | 244.05 ** | 219.61** | 0.50 | 53.06** | 33.46** | 60.41** | 43.83** | 39.45** | 75.96** | 3554.01** | 140515.40** | 10842.24** |
| Environment | 2 | 5327.70** | 2381.66** | 14.77** | 1281.75** | 1867.32** | 2779.79** | 104.37** | 136.97** | 214.42** | 27245.06** | 54582.70** | 421162.8** |
| Genotype x Environment | 38 | 45.31** | 20.98** | 0.26 | 11.74** | 10.25** | 13.54** | 2.62** | 2.04** | 3.80** | 549.47** | 29944.67** | 2310.54** |
| Environment + Genotype x Environment | 40 | 176.24** | 139.01** | 0.98 | 75.24** | 103.11** | 151.85** | 7.71** | 8.79** | 14.33** | 1884.25** | 301360.9** | 23253.16** |
| Environment (Linear) | 1 | 5327.70** | 4763.33** | 29.54** | 2563.49** | 3734.63** | 5559.58** | 208.73** | 273.94** | 428.84** | 54490.13** | 109165.41** | 842325.7** |
| Genotype x Environment (Linear) | 19 | 17.88** | 5.49** | 0.34 | 5.74** | 5.62** | 6.51** | 0.93 | 0.68 | 4.24** | 856.09** | 35243.22** | 2719.27** |
| Pooled deviation | 20 | 69.11 | 34.65 | 0.17 | 16.84 | 14.14 | 19.53 | 4.10 | 3.24 | 3.19 | 230.70 | 23413.81 | 1806.74 |
| Pooled Error | 114 | 0.25 | 0.21 | 0.001 | 0.03 | 0.04 | 0.07 | 0.009796 | 0.02 | 0.019 | 1.08 | 200.31 | 15.45 |

*Note : * and ** depict significance at 5% and 1% levels of probability respectively; DF = Degrees of freedom*

***Characters:*** *Plant height (PH), Plant spread (PS), Number of primary branches / plant (NPB), Days to first flowering (DFF), Days to 50% flowering (D50F), Days to first harvest (DFH), Number of fruit / plant (NFPP), Average fruit weight (AFW), Fruit yield/plant (FYP), Total yield (TY).*

**Table 3: Overall mean and environmental index for different traits under study**

| Character | Grand mean | Environmental index | | |
|---|---|---|---|---|
| | | $E_1$ | $E_2$ | $E_3$ |
| Plant height (cm) | 66.61 | 1.24 | -12.11 | 10.87 |
| Plant spread (cm) | 67.74 | 4.87 | -12.50 | 7.63 |
| Number of primary branches | 3.58 | 0.97 | -0.65 | -0.32 |
| Days to first flowering | 56.11 | -7.57 | 8.38 | -0.81 |
| Days to 50% flowering (DAT) | 67.18 | -9.13 | 10.12 | -0.98 |
| Days to first harvest (DAT) | 89.82 | -5.94 | 13.58 | -7.64 |
| Fruit length (cm) | 14.40 | 1.63 | -2.61 | 0.98 |
| Fruit girth (cm) | 15.96 | 0.72 | -2.90 | 2.18 |
| Average fruit weight (g) | 90.50 | 33.55 | -39.53 | 5.98 |
| Number of fruits per plant | 12.36 | 0.56 | -3.52 | 2.96 |
| Fruit yield per plant (g) | 1020.20 | 368.27 | -597.89 | 229.63 |
| Total fruit yield (q/ha) | 283.39 | 102.30 | -166.08 | 63.79 |

**Table 4: Stability parameters for important growth, reproductive, yield and attributing traits**

| Genotypes | Plant height (cm) | | | Plant spread (cm) | | | Days to 50% flowering | | | Days to first fruit harvest | | | Fruit length (cm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pooled Mean | $b_i$ | $S^2_d$ | Pooled Mean | $b_i$ | $S^2_d$ | Pooled Mean | $b_i$ | $S^2_d$ | Pooled Mean | $b_i$ | $S^2_d$ | Pooled Mean | $b_i$ | $S^2_d$ |
| Arka Neelkanth | 79.97 | 1.35** | 28.89 | 68.33 | 1.01 | 3.40 | 62.22 | 1.19* | 42.07** | 88.33 | 1.00 | 2.01* | 14.01 | 1.03 | 1.77** |
| BRBR-01 | 58.11 | 0.88** | -0.12 | 68.36 | 1.26 | 11.95** | 70.00 | 0.90* | 21.61** | 89.00 | 1.01 | 0.13 | 9.96 | 0.63** | 0.58** |
| Brinjal 71-19 | 61.49 | 0.86** | 5.46 | 63.38 | 0.84** | 89.13** | 67.00 | 1.01 | 0.12 | 89.67 | 1.04* | 6.31** | 21.13 | 1.47** | 2.25** |
| IC-261802 | 65.95 | 0.94** | 3.38 | 71.19 | 1.04 | -0.10 | 73.89 | 1.29** | 20.74** | 88.11 | 1.00 | -0.02 | 13.31 | 0.88* | 1.41* |
| IC-89837 | 70.28 | 1.17** | 17.25 | 60.56 | 0.93** | 39.95** | 69.00 | 1.11** | 3.03* | 91.22 | 1.03* | 5.80** | 12.98 | 0.95* | 1.26* |
| IC-89933 | 74.45 | 0.61** | 330.91** | 58.53 | 0.87** | 5.61** | 68.11 | 0.98* | 3.25* | 92.44 | 1.02* | 30.04** | 12.01 | 0.91* | 1.39* |
| IIHR-562 | 63.59 | 1.00 | 2.82 | 58.49 | 0.84** | 0.39 | 64.22 | 0.85** | 11.10** | 88.56 | 0.80** | 22.42** | 10.01 | 0.65** | 1.16** |
| BRBL-02 | 58.45 | 1.24 | 165.29** | 74.19 | 1.07 | 1.87 | 65.33 | 0.87** | 11.88** | 94.67 | 0.80** | 2.74* | 15.88 | 0.94 | 10.69* |
| Muktakeshi | 75.01 | 1.33** | 54.43 | 76.83 | 1.01 | 158.46** | 68.44 | 1.00 | 1.88 | 98.22 | 1.16** | 128.99** | 14.44 | 1.07 | 0.32 |
| Nurkee | 52.76 | 0.89** | 12.17 | 57.96 | 0.77** | 69.26** | 62.56 | 1.11** | 26.64** | 87.00 | 0.96** | 15.92* | 21.24 | 1.60** | 32.45** |
| Pant Rituraj | 70.34 | 0.64 | 221.94** | 67.02 | 1.08 | 159.8**9 | 67.33 | 0.93** | 6.49* | 84.00 | 0.97** | 3.57* | 9.63 | 0.65** | 6.99** |
| BRBL-07 | 78.78 | 1.30** | 16.04 | 78.04 | 1.14 | -0.08 | 70.44 | 0.84 | 47.64** | 96.56 | 1.13** | 18.49** | 17.23 | 0.91* | 6.29** |
| Pusa Purple Cluster | 85.07 | 0.97 | 119.20** | 69.43 | 1.02 | 0.70 | 60.11 | 1.05* | 15.94** | 93.56 | 1.02 | 94.77** | 13.35 | 0.92 | 0.01 |
| Punjab Brinjal-67 | 62.77 | 0.89** | 3.78 | 63.80 | 0.98** | 37.78** | 66.22 | 0.87* | 13.83** | 83.44 | 0.96** | 2.77* | 16.17 | 1.15 | 0.002 |
| Pusa Shyamla | 61.42 | 0.91** | 0.06 | 71.67 | 1.09 | 26.59** | 66.00 | 1.09* | 4.53* | 80.22 | 0.94** | 20.57** | 16.98 | 1.27** | 0.29* |
| Rajendra Baigan-2 | 61.21 | 0.97 | 2.77 | 62.39 | 0.88** | 14.03** | 69.00 | 1.25** | 31.34** | 87.67 | 1.38** | 1.31* | 21.70 | 1.58** | 1.44* |
| BRBL-04 | 57.18 | 0.72* | 22.73 | 58.07 | 0.83** | 2.27 | 64.44 | 0.90** | 5.37** | 88.89 | 1.01 | 2.78* | 13.42 | 1.06 | 0.001 |
| RCMBL-04 | 67.66 | 0.87* | 26.66 | 75.00 | 1.06** | 10.82** | 69.22 | 1.17** | 10.15** | 91.67 | 1.06 | 0.66* | 14.51 | 1.05 | 0.22* |
| BRBL-01 | 54.49 | 0.85** | 0.92 | 60.40 | 0.89** | 0.74** | 70.56 | 0.53** | 4.31** | 88.22 | 0.61** | 6.83** | 10.29 | 0.61** | 0.84* |
| Swarna Mani | 73.29 | 1.62** | 342.68** | 91.15 | 1.39** | 56.19** | 69.56 | 1.06 | -0.01 | 95.00 | 1.10** | 23.14** | 9.69 | 0.66 | 12.42** |
| Overall mean | 66.61 | - | - | 67.74 | - | - | 67.18 | - | - | 89.82 | - | - | 14.40 | - | - |

*Note : * and ** depict significance at 5% and 1% levels of probability respectively*

***Continued...***

*Continued. Table 4*

| Genotypes | Plant height (cm) | | | Plant spread (cm) | | | Days to 50% flowering | | | Days to first fruit harvest | | | Fruit length (cm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pooled Mean | $b_i$ | $S^2_d$ | Pooled Mean | $b_i$ | $S^2_d$ | Pooled Mean | $b_i$ | $S^2_d$ | Pooled Mean | $b_i$ | $S^2_d$ | Pooled Mean | $b_i$ | $S^2_d$ |
| Arka Neelkanth | 14.05 | 0.97 | 1.23 | 58.67 | 0.55* | 646.27** | 9.45 | 0.66** | 4.03** | 590.79 | 0.64** | 2158.18** | 164.11 | 0.64** | 1665.22** |
| BRBR-01 | 18.56 | 0.87** | 13.89** | 102.17 | 1.05 | 1020.70** | 6.64 | 0.45** | 2.45** | 717.95 | 0.80** | 136.28 | 199.43 | 0.80** | 105.13 |
| Brinjal 71-19 | 15.25 | 0.78** | 4.86* | 92.13 | 0.86* | 328.29** | 11.95 | 1.11** | 0.47* | 1126.24 | 1.02 | 965.50** | 312.85 | 1.02 | 745.02* |
| IC-261802 | 19.05 | 1.23 | 0.17 | 140.76 | 1.78** | -1.00 | 6.93 | 0.54** | 0.54* | 1045.69 | 1.21** | 1811.43** | 290.47 | 1.21** | 1397.76** |
| IC-89837 | 17.31 | 1.18** | 1.58 | 83.13 | 1.01 | 25.28** | 8.47 | 0.67* | 0.64** | 756.34 | 0.86 | 20.14 | 210.09 | 0.86 | 15.53 |
| IC-89933 | 16.74 | 1.10 | 0.33 | 87.09 | 1.15* | 42.46** | 13.33 | 1.22** | 0.38* | 1210.68 | 1.36 | 143.31* | 336.30 | 1.36** | 110.67* |
| IIHR-562 | 12.96 | 0.96 | 3.67* | 40.07 | 0.30** | 0.76 | 21.66 | 0.73 | 3.11** | 874.97 | 0.62** | 726.10** | 243.05 | 0.62** | 560.23** |
| BRBL-02 | 10.94 | 0.74** | 0.53 | 61.14 | 0.19** | 144.12** | 18.95 | 0.94 | 1.82** | 1097.58 | 0.55** | 376.09* | 304.88 | 0.55** | 290.17* |
| Muktakeshi | 21.75 | 1.23 | 2.94* | 146.15 | 1.81** | 19.02** | 5.97 | 0.52** | -0.02 | 926.16 | 1.04 | 116.68 | 257.27 | 1.04 | 90.05 |
| Nurkee | 11.25 | 0.96 | 11.01** | 73.35 | 0.95* | 5.36* | 13.48 | 1.42* | 7.67** | 998.04 | 1.07 | 2779.19** | 277.23 | 1.07 | 2144.46** |
| Pant Rituraj | 21.58 | 1.26** | 1.45 | 112.93 | 1.57** | 345.91** | 10.02 | 0.91 | 0.10 | 1185.40 | 1.36** | 3028.99** | 329.28 | 1.36** | 2337.27** |
| BRBL-07 | 20.25 | 1.10 | 4.52* | 164.63 | 1.85** | 935.69** | 5.87 | 0.45* | 0.52** | 1044.43 | 1.17** | 828.89* | 290.12 | 1.17* | 639.62** |
| Pusa Purple Cluster | 9.91 | 0.62** | -0.02 | 48.53 | 0.20** | 10.98* | 18.65 | 1.53* | 1.32* | 917.96 | 0.66** | 1022.72** | 254.99 | 0.66** | 789.11** |
| Punjab Brinjal-67 | 14.60 | 0.80** | 1.99 | 81.33 | 1.14* | 191.84** | 12.19 | 1.21 | 2.81* | 1022.35 | 1.14 | 3.11 | 283.99 | 1.14 | 2.44 |
| Pusa Shyamla | 15.08 | 0.77** | 4.79* | 68.80 | 0.99 | 250.35** | 13.02 | 1.63** | 33.49** | 869.59 | 0.89** | 7210.42** | 241.55 | 0.89** | 5563.59** |
| Rajendra Baigan-2 | 12.68 | 0.90* | 1.90* | 86.18 | 1.17* | 94.83** | 11.37 | 1.70** | 0.99* | 1062.43 | 1.35** | 766.22** | 295.12 | 1.35** | 591.29* |
| BRBL-04 | 14.82 | 0.87** | 0.55 | 55.39 | 0.41** | 8.94* | 19.96 | 1.75** | -0.01 | 1153.16 | 1.01 | 30.26 | 320.32 | 1.01 | 23.35 |
| RCMBL-04 | 15.55 | 1.08* | 1.68* | 82.50 | 0.76** | 213.45** | 15.29 | 1.23 | 1.47** | 1308.38 | 1.23** | 8422.55** | 363.44 | 1.23** | 6498.97** |
| BRBL-01 | 15.05 | 1.00 | 0.46 | 86.39 | 0.40** | -1.04 | 17.83 | 0.89 | 0.11 | 1558.36 | 0.88 | 129.27 | 432.88 | 0.88 | 99.80 |
| Swarna Mani | 21.87 | 1.57** | 6.80* | 138.68 | 1.89** | 310.33** | 6.23 | 0.44* | 1.61* | 937.52 | 1.13 | 12756.13** | 260.42 | 1.13* | 9842.72** |
| Overall mean | 15.96 | - | - | 90.50 | - | - | 12.36 | - | - | 1020.20 | - | - | 283.39 | - | - |

*Note : * and ** depict significance at 5% and 1% levels of probability respectively* performance of the genotype over different environments was also an important consideration for ranking it as better and stable genotype.

None of the genotypes showed stability for all of the eleven quantitative traits subjected to stability analysis. In fact, different genotypes were found to be stable for different characters under study (Table 3).

Out of the 20 genotypes, only two, *viz*., IIHR-562, ranked 1 and Rajendra Baigan-2, ranked 2, exhibited desirable *per se* performance, average regression and least deviation from regression line, and hence considered stable for plant height. Swarna Mani, BRBL-02 and IC-261802 exhibited regression coefficient significantly greater than unity, and hence may be referred to as high responsive, that is, fit for favourable condition. Nurkee, Punjab Brinjal-67, BRBL-01, BRBL-04, Brinjal 71-19 and BRBR-01 showed regression coefficient lesser than unity and may be called low responsive, which is suited to unfavourable condition.

For plant spread, Pusa Purple Cluster, Arka Neelkanth, BRBL-02, IC-261802 and BRBL-07 were identified as the stable genotypes over all the environments. The genotypes suited for favourable condition were Pusa Shyamla, Muktakeshi, BRBR-01 and Pant Rituraj, while those for unfavourable condition were BRBL-07, IIHR-562 and Brinjal 71-19.

Two genotypes, Arka Neelkanth and IC-89837 were found to be stable with desirable per se performance for days to first flowering. IC-89933, Swarna Mani, BRBR-01, Muktakeshi and Nurkee were average responsive.

Brinjal-71-19 was the only genotype stable in respect of days to 50 % flowering with mean value lesser than the overall mean since for earliness lesser value is desired, while Muktakeshi and Swarna Mani were also average responsive, but possessed higher mean value than overall mean, which is not desirable for days to 50% which contributes towards earliness. The genotypes IC- RCMBL-04, 261802, Rajendra Baigan-02 and IC-89837, could be recognised for favourable environment while BRBL-01, BRBL-07, Pant Rituraj and IC-89933 could be identified for unfavourable environment.

IC-261802 and BRBR-01 were identified as highly stable with desired *per se* performance for days to first harvest. On the other hand, BRBL-04, RCMBL-04, Arka Neelkanth and Pusa Purple Cluster were found to be high responsive while, IIHR-562 and BRBL-02 low responsive.

BRBL-04, Punjab Brinjal-67, Pusa Purple Cluster and Muktakeshi were identified as stable for fruit length. On the other hand, RCMBL-04, Arka Neelkanth, BRBL-02, Pusa Shyamla, Nurkee, Rajendra Baigan-2 and Brinjal 71-19 were identified as suitable for favourable environment, while BRBL-02 and BRBL-07 for unfavourable environment.

Four genotypes were identified as stable for fruit girth, i.e., BRBL-01, IC-89933, IC- 261802 and Arka Neelkanth. The high responsive genotypes were Swarna Mani, IC-89837, RCMBL-04 Muktakeshi, BRBL-07 and Pant Rituraj while the low responsive ones were were Brinjal 71-19 and BRBL-01.

None of the genotypes were found stable for average fruit weight. BRBR-01, Pusa Shyamla and IC-89837 could be identified as average responsive genotypes ($b_i$, nearer to unity), but none had desirable mean or non-significant deviation from regression.

For number of fruits per plant, the stable genotypes were BRBL-01 ranked first followed by Pant Rituraj. Muktakeshi and BRBL-04 could be identified as average responsive genotypes, while RCMBL-04, IC-89933 , Pusa Purple Cluster, Nurkee , Pusa Shyamla and Punjab Brinjal-67 suited for favourable environment and IIHR-562 and BRBL-02 for unfavourable environment.

For yield/plant, only four genotypes, *i.e*., BRBL-01 BRBL-04 and Punjab Brinjal-67 could be identified as highly stable, whereas IC-89837 achieved lower yield than overall mean despite having regression coefficient of unity and least deviation from regression line and hence not identified as stable genotype. The average responsive genotypes were BRBL-01 and Muktakeshi, while RCMBL-04, IC-89933, Brinjal 71-19, Rajendra Baigan -2, Pant Rituraj and BRBL-07 could be identified as high responsive and BRBL-02 as low responsive.

For total yield, genotypes BRBL-01 (with mean yield 432.88 q ha$^{-1}$), BRBL-04 (mean yield 320.22 q ha$^{-1}$) and Punjab Brinjal-67 (mean yield 283.99 q ha$^{-1}$) could be identified as good stable genotypes possessing high mean yield, whereas, Muktakeshi and IC-89837 with lesser mean yield than overall mean yield could not be identified as stable genotypes, though it fulfilled the other criteria for being stable variety. On the other hand, BRBR-01 was found to be average responsive. Swarna Mani, Pant Rituraj, IC-261802, Brinjal 71-19, Rajendra Baigan -2, IC-89933, RCMBL-04 and BRBL-07 could be identified as suited to favourable environment while BRBL-02 and Pusa Purple Cluster for unfavourable environment.

Several researchers worked on brinjal for determining phenotypic stability of different genotypes of brinjal at different locations and identified different genotypes stable for different traits (Suneetha *et al.*, 2006; Vaddoria *et al.*, 2009; Bhusan and Samnotra, 2017).

Based on the major yield and attributing traits, BRBL-01, BRBL-04 and Punjab Brinjal-67 could be identified as the most promising and stable genotypes that could be grown in different seasons. These genotypes may be used recommended for growing year round in the middle Gangetic plains of India. They may also be further utilized in breeding programmes for developing stable varieties.

**ACKNOWLEDGEMENT**

The authors are thankful to National Bureau of Plant Genetic Resources, New Delhi, Indian Instiute of

Vegetable Research, Varanasi and Indian Institute of Horticultural Research, Bengaluru, for provision of plant materials and Bihar Agrciultural University, Sabour for financial grant through the non-plan project SP/CI/BAC/ 2012-14.

## REFERENCES


Anonymous, 2018. Horticultural Statistics at a glance. Horticulture Statistics Division, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India.

Basford, K.E. and Cooper, M. 1998. Genotype x environment interactions and some considerations of their implications for wheat breeding in Australia. *Australian J Agric. Res.*, **49:** 153-74.

Bhusan, A. and Samnotra, R. K. 2017. Stability studies for yield and quality traits in brinjal (*Solanum melongena* L.). *Indian J Agric. Res.*, **51** (4): 375-79.

Chaurasia, S. N. S, Singh, M., and Rai, M. 2005. Stability Analysis for growth and yield attributes in brinjal. *Veg. Sci.*, **32**(2): 120-22

Chowdhury, D. and Talukdar, P. 1997. Phenotypic stability of brinjal cultivars and a few crosses in F3 generation over environments. *Hort. J.*, **10** (1) : 65-71.

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

Fisher, R.A. 1946. In: Statistical method for research workers (10th edn.), Olive and Boyd, Edinburgh.

Kang, M.S. 1990. *In*: Kang MS (ed) Genotype by environment interaction and plant breeding. Louisiana State University, Balon Rouge, Louisiana, USA. pp. 386

Krishna Prasad, V. S. R., Singh, D. P., Pal, A. B., Gangopadhyay, K. K. and Pan, R. S. 2000 Assessment of yield stability and ecovalence in eggplant. *Indian J Hort.*, **59**: 386-94.

Mandal, G. and Chaurasia, H.K. 2007. Genotype x environment interaction studies in brinjal (*Solanum melongena* L.). *Ph.D. Thesis*, RAU, Samastipur. http:/krishikosh.egranth.ac.in/ handle/1/15/178

Mohanty, B. K. and Prusti, A. M. 2000. Genotype x environment interaction and stability analysis for yield and its components in brinjal *(Solanum melongena* L.). *J Agric. Scie.*, **70**: 370-73.

Mohanty, B.K. 2001. Genetic variability, correlation and path coefficient studies in brinjal (*Solanum melongena* L.). *Annals* of *Agric.Res.*, **22**(1): 59-63.

Nath, Prem, Srivatava, V.K., Dutta, O.P. and Swamy, K.R.M. 2008. Brinjal. *In:* Vegetable crops improvement and production, PNASF, Bangalore, India, pp.52-55.

Pandit, M. K., Thapa, H., Akhtar, S. and Hazra, P. 2010. Evaluation of brinjal genotypes for growth and reproductive characters with seasonal variation. *J Crop &Weed*, **6**(2): 31-34.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical methods for Agricultural workers. IInd Edn. 152-157. ICAR, New Delhi.

Rai, N., Singh, A.K. and Tirkey, T. 2000. Stability in round shaped brinjal hybrids. *Annals* of *Agric.Res.*, **21**: 530-32.

Ratnavathi, C. V., Dayakar Rao, B., Padmaja, P. G., Ravikumar, S., Reddy, S., Vijaykumar, B. S., Pallav, M., Komala, V. V., Gopalakrishna, D. and Seetharama, N. 2005. "Sweet sorghum" the wonder crop for biofuel production, *NATP Technical Report* No. 27, April, 2005.

Revanappa, S. and Kajjidoni, S .T . 2004. Genotype × environment interaction for seed yield and its components in advance breeding lines of blackgram (*Vigno mungo* L. Hepper). *Madras Ag. J.*, **91**(4-6): 341-44.

Sidhu, A. S. 1989. Phenotypic stability in brinjal. *Indian J Genet. & Pl. Breed*. **49**(1): 81-83.

Singh, A. P. and Chaudhary, V. 2018. Genetic analysis for yield and yield contributing characters in brinjal (*Solanum melongena* L.) over environments. *Int. J Current Microbiology and App. Sci.*, **7** (8): 1493-1504.

Singh, G. P., Kalloo, G., Pandey, U. C., Thakral, K. K. and Khurana, S. C. 1985. Phenotypic stability in brinjal. *Harayana J Hort. Scie.*, **14**(1&2): 118-21.

Singh, N. and Kalda, T.S. 2000. Brinjal. *In:* Text book of vegetables, tuber crops and spices (Eds) S. Thamburaj and N. Singh, ICAR, New Delhi, p. 31.

Srivastava, B. P., Singh, K. P. and Srivastava, J. P. 1997. Stability for fruit yield in brinjal. *Veg. Sci.*, **24**(1): 43-44.

Suneetha, Y., Kathiria, K. B. and Srinivas, T. 2006. Genotype x season interaction and phenotypic stability for yield and quality in eggplant. *Int. J Pl. Scie.*, **1** (2): 177-81.

Vadivel, E. and Bapu, J. R. K. 1989. Genotype x environment interaction for fruit yield in eggplant (*Solanum melongena* L.). *South Indian Hort.*, **37**: 141-43.

Vadodaria, M. A., Kulkarni, G. H., Madariya, R. B. and Dobariya, K. L. 2009. Stability for fruit yield & its component traits in brinjal. *Crop Improvement.* **36**(1):81-87.

Yusufzai, A. S. 1989. Genetic studies in brinjal (*Solanum melongena* L.) under varying environments. Unpublished Ph.D. Thesis submitted to the Gujarat Agricultural University, S K Nagar.