Original Research Article

Genotype × Environment Interactions and Stability Analysis for Seed Yield and Yield Attributing Characters in Castor (Ricinus communis L.)

B.A. Chaudhari*, M.P. Patel, N.V. Soni, A.M. Patel, R.R. Makwana and A.B. Patel

Department of Genetics and Plant Breeding, C. P. College of Agriculture, Sardarkrushinagar, Dantiwada Agricultural University, Sardarkrushinagar– 385506 (Gujarat), India

*Corresponding author

A B S T R A C T

Twenty six genotypes were evaluated for G × E interaction and stability analysis in three environments viz., Castor-Mustard Research Station, S. D. Agricultural University, Sardarkrushinagar (E1), Cotton Research Station, S. D. Agricultural University, Talod (E2) and Agricultural Research Station, S. D. Agricultural University, Kholwada (E3) (Gujarat, India) during kharif-rabi 2016-17. The partitioning of G × E interaction were significant for number of effective branches per plant, 100 seed weight, oil content and leaf area, which indicated that the genotypes under study responded differently to the environments. G × E linear component was significantly higher than its counterpart G × E non-linear component for number of effective branches per plant and leaf area. However, for 100 seed weight and oil content non-linear component was higher than linear component, which made them unpredictable. Among the three environments, higher number of effective branches per plant and leaf area was observed under E1 location, hence, it was considered as better environment; whereas, less number of effective branches per plant was obtained under E3 location, hence, it was considered as poor environment and E2 location was considered as average environment.

Keywords
Stability analysis, G × E interaction, Grain yield, Castor genotype, Over environments

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Introduction

Castor (Ricinus communis L. 2n = 2X = 20) is one of the most important non-edible oilseed crop. It belongs to mono specific genus Ricinus of Euphorbiaceae family (Chaudhari et al., 2019). It has cross pollination up to the extent of 50 per cent due to its monoecious nature.

Phenotype is defined as a linear function of Genotype (G), Environment (E) and G × E interaction effects. The study of G × E interaction serves as a guide for various environmental niches. A particular genotype does not exhibit the same phenotypic expression under different environments and different genotypes respond differently to a particular environment. This variation arising from lack of correspondence between the genetic and non-genetic effects is known as genotype × environment interaction. The crop yield is dependent on the genotype, environments and their interaction (Pagi et
al., 2017a,b). When interaction between genotype and environment is present, ranking of genotype will be different under different environments. The plant breeder always interested in the stability of the performance for the characters which are of economically important. The desirable hybrid should have low genotype × environment interaction for important characters, so as to get desirable performance of hybrids over wild range of environmental conditions. Such hybrids are said to be stable because for their stable performance under changing environments. The presence of G × E interaction is a major problem in getting a reliable estimate of heritability, difficult to predict with a greater accuracy rate of the genetic progress under selection for a given character. Hence, the knowledge of magnitude and nature of G × E interaction is very useful to plant breeders.

The statistical techniques to measure the G × E interaction developed by Finlay and Wilkinson (1963), Eberhart and Russell (1966) and Perkins and Jinks (1968) have been very useful in breeding programmes. In the present investigation, the approach of Eberhart and Russell (1966) was used to understand the G × E interaction and stability of different genotypes.

Materials and Methods

Twenty six genotypes of castor were selected for study. The field experiment was conducted at three different location viz., Castor-Mustard Research Station, S. D. Agricultural University, Sardarkrushinagar (E₁), Cotton Research Station, S. D. Agricultural University, Talod (E₂) and Agricultural Research Station, S. D. Agricultural University, Kholwada (E₃) during kharif-rabi 2016-17 with spacing of 120 cm X 60 cm, in RBD with three replications. Standard agronomic practices were followed to raise the crop. The various quantitative traits viz., Days to flowering (primary raceme), Days to maturity (primary raceme), Number of nodes up to the primary raceme, Effective length of primary raceme (cm), Plant height up to primary raceme (cm), Seed yield per plant (g), 100 seed weight (g), Number of capsules on primary raceme, Leaf area (cm²) and Oil content (%) were included for study. Analysis of variance was performed and stability parameters were conducted following the model proposed by Eberhart and Russell (1966). The type of stability was decided on regression coefficient (bᵢ) and mean values (Finaly and Wilkinson, 1963).

Results and Discussion

The mean sum of squares due to genotypes was highly significant for all the 11 quantitative characters studied across the environments, which indicated the presence of substantial amount of variation in the material studied. The analysis also indicated significant variation among the environments for all the characters. The values of G × E interaction were significant for number of effective branches per plant, 100 seed weight, oil content and leaf area (Table 1), which indicated that genotypes interacted differently with environmental variations for the said characters. Highly significant values of mean square due to environments (linear) for all the characters indicated that environments differed considerably among different locations. The mean square values due to G × E (linear) and G × E (pooled deviation) were found to be significant for number of effective branches per plant, 100 seed weight, oil content and leaf area.

The stability parameters were worked out and interpreted only for the characters which had significant values of G × E mean square and greater magnitude of G × E (linear) component in respect to pooled deviation i.e. G × E (non-linear), thereby only two
The higher number of effective branches per plant is desirable for higher seed yield. The results revealed that total 19 genotypes had non significant deviation from regression coefficient and 10 genotypes had higher number of effective branches per plant than mean, out of these, 18 genotypes were identified ($b_i > 1$ and significant: nine and $b_i < 1$ and significant: nine) as well adapted to different environments. Among the genotypes, nine genotypes GCH-2, GCH-7, SHB-1005, SHB-1019, SHB-1029, GNCH-1, GEETA, 48-1 and JI-96 had below average stability (Mean > genotypes mean; $b_i > 1$ and $S^2d_i = 0$ NS), thereby specifically adapted to favorable environment; while, nine genotypes GAUCH-1, GCH-4, SHB-1018, VP-1, SKI-352, SKI-370, SKI-372, SKI-373 and DCS-94 had above average stability (Mean > genotypes mean; $b_i < 1$ and $S^2d_i = 0$ NS), hence specifically adapted to poor environment (Table 2). Higher leaf area is desirable for higher seed yield. The results revealed that total 22 genotypes had non-significant deviation from regression coefficient and 10 genotypes had higher leaf area than mean. Out of 26 genotypes, nine genotypes were identified ($b_i > 1$ and significant: seven and $b_i < 1$ and significant: two) as well adapted to different environments. Among the genotypes, two genotypes GCH-6 and JP-65 had below average stability (Mean > genotypes mean; $b_i > 1$ and $S^2d_i = 0$ NS), thereby specifically adapted to favorable environment; while, genotypes GCH-4 had above average stability (Mean > genotypes mean; $b_i < 1$ and $S^2d_i = 0$ NS), hence specifically adapted to poor environment (Table 2). The results partially confirmed the findings of Henry and Daulay (1985), Tank (2000), Patel (2001), Thakker (2002), Solanki and Joshi (2003), Kumari et al., (2003), Chaudhari (2006), Patel and Pathak (2006), Sasidharan (2005), Patel et al., (2010), Patel et al., (2011), Dhedhi et al., (2012) and Patel et al., (2015).
Table 1 Analysis of variance for phenotypic stability for different characters

| Source of variation | d.f. | Days to flowering (primary raceme) | Days to maturity (primary raceme) | Number of nodes up to primary raceme | Seed yield per plant (g) | Effective length of primary raceme | Number of capsules in primary raceme | Number of effective branches per plant | 100 seed weight | Oil content (%) | Plant height up to primary raceme (cm) | Leaf area (cm²) |
|---------------------|------|-----------------------------------|-----------------------------------|--------------------------------------|-------------------------|-----------------------------------|--------------------------------------|--------------------------------------|----------------|----------------|-------------------------------------|----------------|
| Genotypes          | 25   | 88.81**                           | 123.20**                          | 14.43**                              | 8868.08**               | 239.95**                         | 947.97**                            | 14.01**                             | 15.83**        | 3600.70**      | 10.55**                            | 51600913.77**  |
| Environments       | 2    | 9.16*                            | 11.34**                           | 3.44**                               | 3878.20**               | 92.57**                          | 239.1**                             | 13.91**                             | 20.73**        | 406.11*        | 7.56**                             | 73942126.65**  |
| G x E (Gen. x Env.) | 50   | 1.13                             | 3.58                              | 0.43                                 | 54.48                   | 1.67                             | 11.89                               | 0.24**                             | 1.05**         | 46.85          | 0.63**                             | 4493594.59**   |
| Env. + (Gen. x Env.) | 52  | 1.44*                            | 3.88                              | 0.55                                 | 201.54**                | 5.17*                            | 20.63                               | 0.77**                             | 1.81**         | 60.67          | 0.90**                             | 7164691.98**   |
| Environments (Lin.) | 1   | 18.31*                           | 22.69**                           | 6.87**                               | 7756.39**               | 185.13**                         | 478.2**                             | 27.82**                             | 41.45**        | 812.23**       | 15.13**                            | 147884253.30** |
| G x E (Lin.)       | 25   | 0.68                             | 3.52                              | 0.42                                 | 56.68                   | 1.54                             | 11.98                               | 0.26**                             | 0.61**         | 21.52          | 0.42**                             | 4775684.78**   |
| Pooled Deviation   | 26   | 1.52                             | 3.51                              | 0.43                                 | 50.27                   | 1.73                             | 11.36                               | 0.23**                             | 1.44**         | 69.41          | 0.82**                             | 4049523.47**   |
| Pooled Error       | 150  | 0.97                             | 6.39                              | 0.70                                 | 248.33                  | 3.38                             | 12.78                               | 0.11                                | 0.26           | 96.50          | 0.27                               | 1943771.96     |

*, ** Indicate significant at 0.05 and 0.01 levels, respectively.
In conclusion, for number of effective branches per plant, genotypes GCH-2, GCH-7, SHB-1005, SHB-1019, SHB-1029, GNCH-1, GEETA, 48-land JI-96 had below average stability ($b_i<1$) and specifically adapted to favourable environment. Among genotypes, GAUCH-1, GCH-4, SHB-1018, VP-1, SKI-352, SKI-370, SKI-372, SKI-373 and DCS-94 had above average stability ($b_i>1$) and well adapted to unfavorable environment. Genotypes, GCH-6, JP-65, JI-35, SKI-215, SKI-370, SKI-373 and DCS-94 had below average stability for leaf area ($b_i<1$) and specifically adapted to favourable environment. Among genotypes, GAUCH-1 and GCH-4 had above average stability ($b_i<1$) and well adapted to unfavorable environment for leaf area.
Out of the three environments, higher number of effective branches per plant and leaf area was observed under E_1 location, hence it was considered as better environment; whereas, less number of effective branches per plant was obtained under E_3 location hence, it was considered as poor environment and E_2 location was considered as average environment.

References

Baker, R.J.H. (1969). Genotype × Environment interactions in yield of wheat. *Journal of Plant Science*. 49: 743-751.

Chaudhari, B.A., Patel, M.P., Dharajiya, D.T. and Tiwari, K.K. (2019). Assessment of genetic diversity in castor (*Ricinus communis* L.) using microsatellite markers. *Biosciences Biotechnology Research Asia*, 16(1): 61-69. DOI: http://dx.doi.org/10.13005/bbra/2721.

Chaudhari, K.N. (2006). Diallel analysis for seed yield and wilt resistance in castor (*Ricinus communis* L.). Ph.D. Thesis (Unpublished), submitted to Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat State).

Dhedhi, K.K., Joshi, H.J. and Dangaria, C.J. (2012). Phenotypic stability in castor. Punjab Rao Deshmukh Krushi Vidhyapeeth. *Research Journal*. 36 (1): 1-4.

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

Finlay, K.W. and Wilkinson, G.N. (1963). The analysis of adaptation in plant breeding programme. *Australian Journal of Agricultural Research*. 14: 742-754.

Henry, A. and Daulay, H.S. (1985). Genotype × Environment interactions for seed yield in castor bean. *Madras Agricultural Journal*. 72 (4): 196-198.

Kumari, T.R.; Subramanyam, D. and Sreedhar, N. (2003). Stability analysis in castor (*Ricinus communis* L.). *Crop Research*. 25: 96-102.

Pagi, N., Dharajiya, D., Ravindrababu, Y., Pachchigar, K., Soni, N., Parmar, L., Patel, J., Chauhan, R. and Patel, M. (2017a). Phenotypic stability and GGE biplot analysis in pigeonpea [*Cajanus cajan* (L.) Millsp.] genotypes across the environments. *Journal of Experimental Biology and Agricultural Sciences*, 5(3): 359-367. DOI: http://dx.doi.org/10.18006/2017.5(3):359.367.

Pagi, N., Prajapati, N., Pachchigar, K., Dharajiya, D., Solanki, S.D., Soni, N. and Patel, P. (2017b). GGE biplot analysis for yield performance of grain amaranth genotypes across different environments in western India. *Journal of Experimental Biology and Agricultural Sciences*, 5(3): 368-376. DOI: http://dx.doi.org/10.18006/2017.5(3):368.376.

Patel, A.A. (2001). Line × tester analysis over environments in castor (*Ricinus communis* L.). Ph.D. Thesis (Unpublished), submitted to Gujarat Agricultural University, Sardarkrushinagar (Gujarat State).

Patel, A.R. (2009). Genetic analysis of seed yield and component characters over environments in castor (*Ricinus communis* L.). Ph.D. Thesis (Unpublished), submitted to Anand Agricultural University, Anand (Gujarat State).

Patel, C.M., Patel, J.M. and Patel, C.J. (2015). Gene × Environment interaction and stability analysis for yield and yield determinant traits in castor (*Ricinus communis* L). *IOSR Journal of Agriculture and Veterinary Science*. 8 (6): 68-72.

Patel, D.K., Ravindrababu, Y. and Patel, P.J.
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Patel, J.D., Dangaria, C.J., Dholaria, S.J. and Patel, V.J. (1984). Phenotypic stability of seed yield in eight hybrids of castor. Indian Journal of Agricultural Sciences. 54 (8): 629-632.

Patel, J.A., Patel, B.N., Patel, A.R. and Kumar, R. (2010). Genotype × Environment interaction and stability parameters for yield and component characters in castor (Ricinus communis L.). Journal of Oilseeds Research. 2: 47-49.

Patel, J.B. and Pathak, H.C. (2006). Genotype × Environment interaction and stability parameters in castor (Ricinus communis L.). Journal of Oilseeds Research. 23 (1): 35-38.

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

Sasidharan, N. (2005). Genetic analysis for yield and quality in castor (Ricinus communis L.) under diverse environments. Ph.D. Thesis (Unpublished), submitted to Anand Agricultural University, Anand (Gujarat).

Solanki, S.S. and Joshi, P. (2003). Phenotypic stability of hybrids and parents for seed yield and its components in castor (Ricinus communis L.). Journal of Oilseeds Research. 20 (1): 45-47.

Sprague, G.F. (1966). Quantitative Genetics in Plant Improvement. In: Plant Breeding. A symposium held at the Iowa State University (Ed. K.J. Frey). pp. 351-354.

Tank, C.J. (2000). Diallel analysis over environments in castor (Ricinus communis L.). Ph.D. Thesis (Unpublished), submitted to Gujarat Agricultural University, Sardar krushinagar (Gujarat).

Thakker, D.A. (2002). Heterosis and combining ability studies in castor (Ricinus communis L.). Ph.D. Thesis (Unpublished), submitted to Gujarat Agricultural University, Sardar krushinagar (Gujarat).

Thakker, D.A., Gami, R.A. and Patel, P.S. (2010). G × E and stability studies on castor hybrids for yield and its attributing characters. Journal of Oilseeds Research, 27: 74-77.

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