Stability Analysis for Seed Yield trait in Indian Mustard (*Brassica juncea* L. Czern & coss.)

ABSTRACT

Present study was undertaken to estimate the magnitude of genotype × environment interaction (GEI) and to identify stability of improved and high-yielding varieties of Indian mustard (*Brassica juncea* L. Czerns & coss.). The 57 Indian mustard genotypes were evaluated in RBD along with three replications during Rabi crop seasons in three environments. Analysis of variance on 14 traits was carried out individually as well as pooled over environments. Yield stability was analysed employing Eberhart and Russell's model (1966) which revealed highly significant differences among genotypes and environments. Mean squares due to environment + genotype x environment interactions (E + G x E) indicated that genotypes interacted considerably with environmental conditions. Further, partitioning of E+G x E effects indicated that E (linear), G x E (linear) components were highly significant for grain yield. Genotypes RH-749, DRMR 1165-40 X RH-406, DRMR IJ-31 X RH-749 had high mean than general mean coupled with regression coefficient close to unity bi = 1 and $S^2_{di} = 0$ and are identified as most stable and desirable Indian mustard genotypes.

Keywords: Stability, G X E interaction, Stability Indian mustard genotypes.

1. INTRODUCTION

Indian mustard (*Brassica juncea* L.) constitutes one of the more significant species within the genus *Brassica* of the family Brasicaceae, also known as mustard family and comprise about 350 genera and 3500 species (Warwick *et al*. 2000). It is primarily grown on the Indian subcontinent which represents most of the land used for the rapeseed-mustard group of crops.

"In India, the rapeseed-mustard crops represent conventionally cultivated indigenous species namely *viz*., brown sarson (*Brassica rapa* L. var. brown sarson), toria (*Brassica rapa* L.var. toria), yellow sarson (*Brassica rapa* L. var. yellow sarson), black mustard (*Brassica nigra*), Indian mustard [*Brassica juncea* (L.) Czern & Coss] and taramira (*Eruca sativa*) have been grown since long back approximately 5500 years along with some non-traditional species like Ethiopian mustard or Karan rai (*Brassica carinata* A. Braun) and gobhi sarson (*Brassica napus* L.)" (Chand *et al*. 2001).

Rapeseed-mustard category on the basis of nature of the pollination mode is divided into two subgroups which include self-pollinated ones– Indian mustard, yellow and raya sarson, among this Indian mustard, is the vital role as it accounts for about 75-80 % of the area beneath rapeseed-mustard and cross pollinated *viz*., brown sarson, taramira and toria. Among self-pollinated ones, *Brassica juncea* (2n = 4x = 36, AABB) an amphidiploid derived from two different *Brassica* species having low chromosome number i.e. *Brassica nigra* (2n = 2x=16, BB) and *Brassica rapa* (2n =2x = 20, AA) is an important one (Srivastava *et al*., 2001). *Brassica juncea* is a prevailing self-pollinated crop, some frequent cross pollination 5 to 30 percent does occur depending on the environmental circumstances and also the pollinating vector especially the population of pollinator insects.

In the current scenario of changing agro-climatic circumstances, where there is a scarcity in underground water and a rising of the terminal temperature, plant breeders face two challenges regarding the production of oilseeds: initially, the yield potential should be further increased within conventional mustard cultivation areas and other short-duration and drought-tolerant oilseed varieties ought to be developed for sustaining production.

"The appearance of grain yield and it's attributing characteristics is a result of a combination of the genotype (G) of the cultivar, the environment (E) where it is grown, and the interaction between G and E. Genotype via the environment (GE) interaction is of major importance because it provides knowledge about the impact of test environments on the genotype performance and plays a significantly vital role for evaluation of performance and yield stability of the new variety or genotypes" (Sabaghnia *et al*., 2013).

Linear Regression model of Eberhart and Russell (1966) is commonly used for analysis of G×E interaction. In which the b-values (regression) give information about adaptability and S^{2}di (deviation from the regression) are used as measures of stability of performance. Enhancing genetic gain via yield performance is possible in part by narrowing the adaptive capacity of genotypes and so enhancing yield in particular environments is illustrated by GE interaction.

2. MATERIALS AND METHODS

The experiments were conducted at the Field Experimentation Centre, of the Institute Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj U.P. during rabi season 2022-23 under three environment condition. The material for present study consisted of 10 parents (Table 1), two check (PM 25 and GIRIRAJ) and 45 F1 Hybrid. Trials were laid out in randomized block design (RBD) with 3 replications with row-to-row and plant-to-plant distance was kept at 45 ×10 cm2. The data was recorded on 14 characters, viz., days to 50% flowering, days to maturity, plant height (cm), primary branches per plant, secondary branches per plant, siliqua length (cm), siliquae per plant, main shoot length (cm), harvest index (%), biological yield, seeds per silique, 1000-seed weight (g), seed yield per plant (g) and oil content (%). The morphological traits were recorded on randomly selected five competitive plants in the middle rows of each plot in all 3 replications.

"Genotype-environment interactions were found to be significant in respect of all the characters studied, hence the data were subjected to stability analysis (Eberhart and Russel, 1966) to assess the stability of different genotypes. A genotype with regression coefficient of unity (bi =1) and the deviation not significantly different from zero (S^2_{di} = 0) was taken to be a stable genotype with unity response". [10]

3. Results and discussion

For each environment analysis of variance on 14 traits was carried out individually as well as pooled over the environment. Pooled analysis of variance over the three environments was also carried out in order to verify presence of G × E interactions. G × E interaction variance was significant for all the observed traits, except day to maturity, plant height, secondary branch per plant, seed per siliquae, test weight and oil content. These results indicated presence of substantial amount of genotype × environment interaction. Stability analysis was carried out as per Eberhart and Russell

(1966) model for all the observed characters in order to verify presence of variance due to components of G×E interaction (Table 2 and 3).

The genotype × environment interaction was present and it was highly significant for all the characters studied, except day to maturity, plant height, secondary branch per plant, seed per siliquae, test weight and oil content. Similar findings have been reported by Yadava *et al.* (2010). As the environments selected in the present study were presence of significant G × E for the observed traits indicate the exhibited of stability analysis.

Analysis of variance for stability indicated significant differences among the all genotypes for all 14 traits observed, indicating the diversity in the selected genotypes. Significant differences were observed among the environments too, hence significant effect of environment was there in the expression of the traits. Genotype × environment interaction was significant day to 50% flowering, primary branch per plant, main raceme length, siliqua on main raceme, siliqua per plant, siliqua length, seed yield per plant and harvest index indicating that the genotypes are varying over the environments due to G × E. The significant G × E interaction has been reported for various traits by Dhillon *et al*. (2001) and Yadava *et al*. (2010) which confirm the findings of present investigation. G × E (linear) was also significant for day to 50% flowering and harvest index indicating substantial amount of predictable G × E interaction. Hence, we can predict the performance of genotypes over wide range of environments for these traits. Significant G × E (linear) for different traits has been reported by Chaudhary *et al*. (2004) and yadav *et al*. (2019). Among the above traits, day to 50% flowering and harvest index were having high significant pooled deviation which indicated that some portion of G × E was unpredictable. Significant deviations from regression have been reported earlier also by Yadav *et al*. (2019) and Kamdi *et al*. (2022).

However, in the present study genotypes were tested for three parameters of stability for all the observed traits. In order to classify the genotypes into various categories with respect to stability and suitability for particular environments, all 45 genotypes were tested for 3 stability parameters, *viz*., mean, bi and S^2di. The genotypes showing superiority and stability for different traits have been summarized in Table 3; Fig1 and Fig 2. Out of all the genotypes, the genotypes viz., RH-749, DRMR 1165-40 X

RH-406, DRMR IJ-31 X RH-749 were identified to be high yielding and stable genotypes. Stability of the genotypes for various traits on the basis of three parameters have earlier been reported by Dhillon *et al*. (2001), Yadav *et al*. (2010) and Srivastava and Srivastava (2020). which confirm the present findings where various genotypes are showing stability for one or more traits.

4. Conclusion

The present study genotypes RH-749 (parent), DRMR 1165-40 X RH-406, DRMR IJ-31 X RH-749 (hybrid) exhibited higher mean and showed stable performance over environments for most of the yield components traits. Thus, these genotypes can be utilized to develop stable strains having wider adaptability for these environment condition.

Table 1: List of 10 parent's genotypes along with origin/source and pedigree

Sr. No	Name of the genotype	Origin/Source	Pedigree
1.	DRMR IJ-31	ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan	HB-9908 X HB-9916
2.	DRMR 150-35	ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan	RH 819 x Pusa Bold
3.	DRMR 1165-40	ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan	EC552583 x BPR897-4-3
4.	NRCDR-02	ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan	MDOC-43 x NBPGR-36
5.	PUSA BOLD	Indian Agricultural Research Institute, New Delhi	Varuna x BIC 1780
6.	RH-749	CCS Haryana Agricultural University, Hisar, Haryana	RH-781 X RH-7617
7.	RH-761	CCS Haryana Agricultural University, Hisar, Haryana	JMR 9738 x RH 30
8.	JM-2	Zonal Agriculutural Research Station, Jawaharlal Nehru Krishi	Varuna x L-4

		Vishwa Vidyalay, Morena, Madhya Pradesh	
9.	BRIJRAJ	ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur, Rajasthan	NRCHB 101 X Pusa Swarnim
10.	RH-406	CCS Haryana Agricultural University, Hisar, Haryana	RH-6908 x RH-8812

Table 2. Analysis of variance (mean sum of squares) for genotype × environment interactions

Source of variance	Mean sum of squares							
	d.f.	DTF	DTM	PH	PBPP	SBPP	MRL	SMR
R. within E.	6	2.695	2.433	228.181*	0.395	0.678	8.645	9.833
Genotypes	56	7.688**	17.778*	187.375**	0.437	6.338**	74.367**	19.245**
E. + (G.* E.)	114	7.527**	24.379*	169.548**	0.431**	10.43**	59.47**	15.27**
Environments	2	158.64**	645.67**	6303.07**	7.34**	396.77**	1565.16**	403.75**
G.* E.	112	4.82*	13.28	60.02	0.30*	3.53	32.58**	8.34*
Environments (Linear)	1	317.29**	1291.35**	12606.15**	14.69**	793.55**	3130.33**	807.51**
G.* E. (Linear)	56	6.43**	15.06	34.37	0.15	1.08	20.20	3.95
Pooled Deviation	57	3.17**	11.31	84.17*	0.44**	5.87**	44.17**	12.50**
Pooled Error	336	1.38	11.843	57.433	0.11	0.78	8.549	2.751
Total	170	7.58	22.205	175.42	0.433	9.082	64.379	16.584

Table 2 Analysis of variance (mean sum of squares) for genotype × environment interactions (cont.)

Source of variance	Mean sum of squares							
	d.f.	SPP	SL	SPS	SYPP	HI	TW	OC
R. within E.	6	125.00	0.36	1.63	8.52	7.90	0.23	0.51
Genotypes	56	3369.81**	0.432**	1.52*	12.49*	21.71**	0.20**	0.94**
E. + (G.* E.)	114	3417.53	0.26	1.23	8.67	12.51*	0.20	0.92
Environments	2	69113.52**	7.56**	25.30**	212.14**	120.00**	2.29**	11.02**
G.* E.	112	2244.39**	0.13**	0.79	5.04**	10.58*	0.17	0.74
Environments (Linear)	1	138227.00**	15.12**	50.60**	424.28**	240.00**	4.58**	22.04**
G.* E. (Linear)	56	728.01	0.05	0.42	2.82	13.90**	0.093	0.526
Pooled Deviation	57	3694.78**	0.21**	1.14	7.13**	7.13	0.236**	0.94**
Pooled Error	336	92.51	0.02	0.38	0.63	3.41	0.05	0.15
Total	170	3401.81	0.32	1.32	9.92	15.53	0.20	0.92

Table 3 Stability parameters of yield following joint regression analysis

Sr. No.	Name of genotypes	Seed yield per plant			Sr. No.	Name of genotypes	Seed yield per plant		
		Mean	Bi	s²di			Mean	bi	s²di
1	DRMR IJ-31	13.757	1.23	-0.7576	30	NRCDR-02 X RH-749	14.228	1.73	15.1456**
2	DRMR IJ-31 X DRMR 150-35	10.771	0.57	-0.7447	31	NRCDR-02 X RH-761	16.956	1.96	27.4793**
3	DRMR IJ-31 X DRMR 1165-40	12.056	0.99	-0.4098	32	NRCDR-02 X JM-2	15.347	1.92	39.0471**
4	DRMR IJ-31 X NRCDR-02	13.309	1.28	0.2759	33	NRCDR-02 X BRIJRAJ	18.619	1.46	0.1882
5	DRMR IJ-31 X PUSA BOLD	14.167	1.83	2.6524*	34	NRCDR-02 X RH-406	12.087	0.65	-0.5219
6	DRMR IJ-31 X RH-749	15.576	0.98	3.8152*	35	PUSA BOLD	17.217	0.68	13.3041**
7	DRMR IJ-31 X RH-761	16.51	1.6	0.9365	36	PUSA BOLD X RH-749	16.846	0.47	10.3532**
8	DRMR IJ-31 X JM-2	14.483	1.5	1.9816	37	PUSA BOLD X RH-761	16.134	0.38	24.9068**
9	DRMR IJ-31 X BRIJRAJ	14.706	2.04	24.6419**	38	PUSA BOLD X JM-2	18.097	1.21	3.8805*
10	DRMR IJ-31 X RH-406	13.014	0.59	0.7885	39	PUSA BOLD X BRIJRAJ	16.47	0.46	24.6981**
11	DRMR 150-35	11.971	0.82	-0.6744	40	PUSA BOLD X RH-406	13.179	1	1.1776
12	DRMR 150-35 X DRMR-1165-40	13.111	0.92	0.006	41	RH-749	15.203	0.91	-0.5931
13	DRMR 150-35 X NRCDR-02	13.063	0.99	-0.7509	42	RH-749 X RH-761	14.337	1.9	10.2592**
14	DRMR 150-35 X PUSA BOLD	15.256	0.11	8.1322**	43	RH-749 X JM-02	17.418	1.12	-0.763
15	DRMR 150-35 X RH-749	17.687	0.57	-0.5659	44	RH-749 X BRIJRAJ	14.821	1.67	18.5487**
16	DRMR 150-35 X RH-761	17.752	0.94	-0.6321	45	RH-749 X RH-406	15.468	2.13	15.5583**
17	DRMR 150-35 X JM-2	15.758	-0.06	-0.742	46	RH-761	17.107	1.13	-0.4766
18	DRMR 150-35 X BRIJRAJ	18.508	1.43	0.3624	47	RH-761 X JM-2	16.264	0.36	1.6366
19	DRMR 150-35 X RH- 406	15.023	2.18	9.5837**	48	RH-761 X BRIJRAJ	16.218	0.28	14.8629**
20	DRMR 1165-40	14.018	0.35	6.9072**	49	RH-761 X RH-406	18.037	0.84	-0.2095
21	DRMR 1165-40 X NRCDR-02	12.968	-0.21	1.1666	50	JM-2	15.21	1.04	3.0237*
22	DRMR 1165-40 X PUSA BOLD	11.578	0.15	1.3277	51	JM-02 X BRIJRAJ	12.866	0.81	5.5529**
23	DRMR 1165-40 X RH-749	14.243	0.08	1.8474	52	JM-02 X RH-406	14.543	0.2	21.1266**
24	DRMR 1165-40 X RH-761	17.789	1.08	2.4425*	53	BRIJRAJ	12.469	0.64	1.4153
25	DRMR 1165-40 X JM-2	13.014	0.44	17.9774**	54	BRIJRAJ X RH-406	12.368	0.39	-0.7688

26	DRMR 1165-40 X BRIJRAJ	18.928	1.56	-0.5371	55	RH-406	13.354	0.98	-0.7762
27	DRMR 1165-40 X RH-406	16.921	0.97	3.5050*	56	PM-25	15.046	1.41	-0.6534
28	NRCDR-02	12.843	0.78	-0.518	57	Giriraj	13.757	1.23	-0.7576
29	NRCDR-02 X PUSA BOLD	14.468	2.36	34.0029**		Population Mean	14.963		

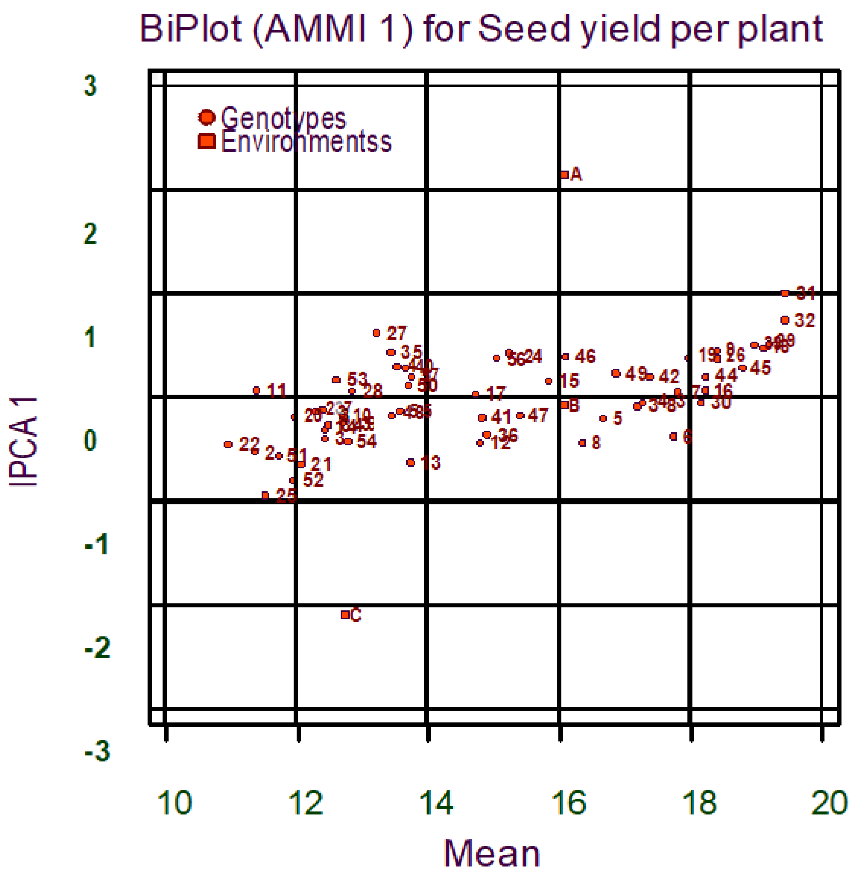

Fig.1 Biplot of the seed yield per plant

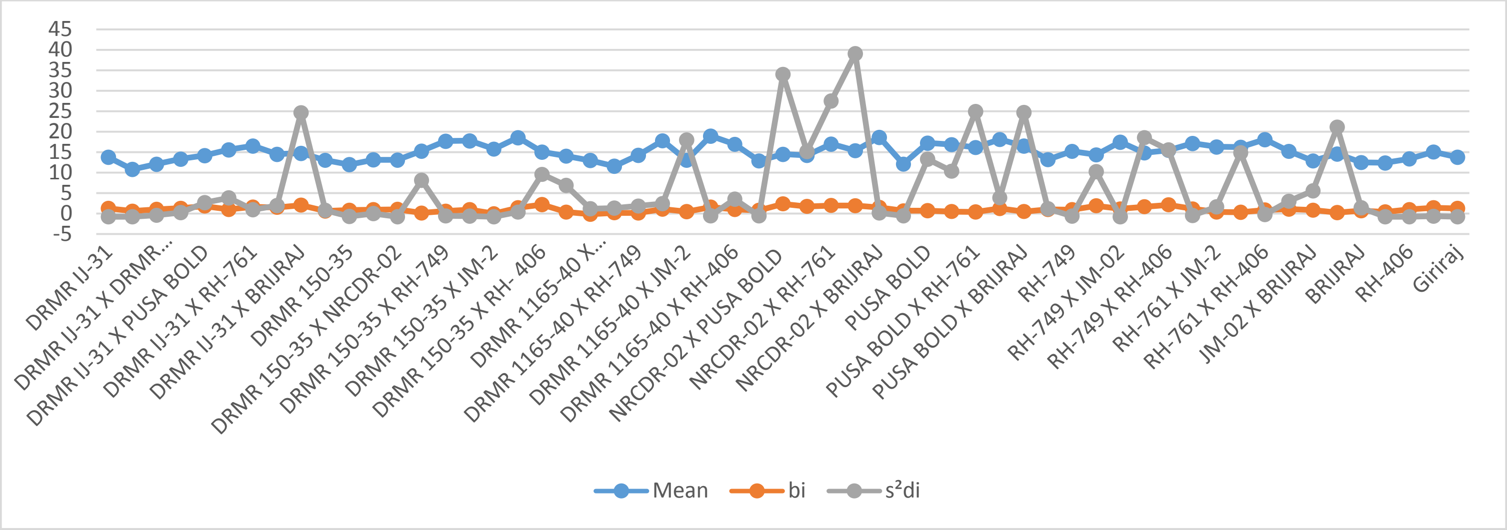

Fig. 2 Stability parameters of yield following joint regression analysis (Eberhart and Russell, 1966)

REFERENCES

1. Chand, S., Patidar, O. P., Chaudhary, R., Saroj, R., Chandra, K., Meena, V. K., Omkar M. Limbalkar, O. M., Patel, M. K., Pardeshi, P. P. and Vasisth, P. (2021). Rapeseed-mustard breeding in India: Scenario, achievements and research needs. *Brassica breeding and biotechnology*, 174.
2. Chaudhary, S.P.S., Choudhary, A.K., Singh, R.V., Singh, N.P. and Shrimali, M.K. 2004. Genotype × environment interaction for yield contributing characters in Indian mustard [*Brassica juncea* (L.) Czern & Coss]. *Research on-Crops*, **5**(2/3): 232–239.
3. Dhillon, S.S., Brar, K.S., Singh, K. and Raheja, R.K. 2001. G×E interaction and stability of elite strains in Indian mustard. *Crop Improvement*, **28**(1): 89–94.
4. Eberhart, S.S. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Science*, **6**: 36–40.
5. Henry A and Daulay H S. 1988. Genotype × environment interaction for seed yield in Indian mustard (*Brassica juncea* subsp. juncea). *Indian Journal of Agricultural Sciences*, **58**: 794–805.
6. Kamdi, S., Ingole, H., Bhure, S., Meshram, M., Tajane, D. and Patil, P. (2022). Stability analysis in Indian mustard. *The Pharma Innovation Journal*, **11**(7): 4351-4354.
7. Srivastava, A. and Srivastava, K. (2020). Stability analysis in Indian Mustard (*Brassica junceal*. czern & coss.) over normal and terminal heat stress environments. *Plant Archives*. **20**(1): 3343-3347.
8. Warwick, S.I., Francis, A. and La Fleche, J. (2000). Guide to wild germplasm of Brassica and allied crops (tribe brassicaceae). http:// res2. agr. ca/ ecorc/ staff/ warwick/ warw-s1.htm.
9. Yadav, O. P., Razdan, A. K. and Kumar, B. 2019. Genotype by environment interaction and stability analysis of grain yield in barley (*Hordeum vulgare* L.). *Journal of Pharmacognosy and Phytochemistry*, **8**(5): 686-688.
10. Yadava, D. K., Giri, S. C., Vasudev, S., Kumar Yadav, A., Dass, B., Raje, R. S., Vignesh, M., Mohapatra, Prabhu, K. V. 2010. Stability analysis in Indian mustard (*Brassica juncea*) varieties. *Indian Journal of Agricultural Sciences*, **80**(9): 761.