JOURNAL OF AGRICULTURE AND BASIC SCIENCES
ISSN Online: 2518-4210
http://www.jabsjournal.com/

Full Length Research Article

Selection of stable mustard (*Brassica juncea* L.) genotypes through genotype × environment interaction and stability analysis suitable for Punjab, Pakistan

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Abstract

Total 10 promising genotypes of *Brassica juncea* L. were evaluated through regression analysis for their stability at five different locations across Punjab province in Pakistan during 2013-14. Combined analysis of variance (ANOVA) depicted highly significant genotype × environment (G × E) interaction (GEI). The average seed yield of these five locations, ranged from 1359 to 2532 kg ha^{-1}. Out of all the tested genotypes, six genotypes produced higher seed yield relative to overall mean value (1930 $kgha^{-1}$). Highest average seed yield 2532 and 2370 kg ha^{-1} was recorded at Faisalabad and Khanpur respectively, followed by experimental area of Agronomy Section (1738 kg ha^{-1}). The regression coefficient (b_i) of *B. juncea* genotypes ranged from 0.399 to 1.433. Genotype ZBJ-09007 was the most stable and adapted genotype due to above average performance (2204kg ha^{-1}), b_i- value nearer to unity (bi = 0.932) and less deviation from regression ($S^2d_i = 0.099$), therefore, this genotype has broader adaptability and recommended for general cultivation in diverse regions across the Punjab. The genotypes ZBJ-10020 and ZBJ-11030 with significant b value (b>1*) were considered highly responsive hence suitable for favorable environments with appropriate production practices.
Keywords: *Brassica juncea*, stability analysis, genotype, environment interaction, Punjab.
Received: 19-March-2016, Accepted: 21-May-2016

Introduction

Stability of yield under different environments is an important concern in plant breeding programs. The goal of plant breeders in crop improvement programs is to develop varieties, which are widely adapted to diversified environments. Some genotypes perform well in some environments but not so well in others (Dhillon *et al.*, 1999). This variability in response is due to genotype × environment (G × E) interaction. These interactions of genotypes with environments can be attributed to environmental stresses like drought, temperature, rainfall, soil texture and diseases. A variety which shows high seed yield and high stability across different environments is considered as stable cultivar (Yan *et al*., 2007). Many scientists (Finlay and Wilkinson, 1963; Ali *et al.*, 2001 & 2003; Ahmad *et al*., 1996; Khan *et al.*, 1998; Hussain *et al*., 1996; Mirza *et al*., 2002 and Yao and Xu, 1994) illustrated the importance of G × E interaction in stability analysis. Stability parameters and partitioning of variation due to (G × E) interaction can be measured by different models such as Finlay and Wilkinson (1963); Eberhart and Russel (1966); Freeman and Perkins (1971); Shulka (1972). Eberhart and Russel (1966) model is relatively simple and permits more effective comparisons of different genotypes for yield and adaptation across variable locations, therefore preferred to use in different crops. Rashid *et al*., (2000), Hebert *et al*., (1995) and Ali *et al*., (2002) reported that regression coefficient is the most useful stability parameter for selection of stable genotypes in Brassica. They further elaborated that the genotypes which show regression coefficient value near to unity and mean square deviation from regression is near to zero is relatively stable. Genotype × environment (G × E) interaction in Brassica cultivars is studied in Chile by Escobar *et al*., (2011). He reported that G × E interaction was significant for seed yield in many locations in one cropping season. Same findings were also reported by Javid *et al.*, (2004).

Stability analysis is an important technique to recognize superior varieties over changing environments with wider adaptability and recommend suitable genotypes for general cultivation as well as for breeding programs. The present studies provide an opportunity to the plant breeders to evaluate and identify a stable genotype suitable in five agro-ecological zones of the Punjab by using regression analysis following Eberhart & Russell (1966).

Material and Methods

Seed material used in this study was comprised of 10 genotypes of Mustard (*B. juncea*) which were evaluated for yield performance at five locations across Punjab during Zaid Kharif season

20013-14. The names of these genotypes are ZBJ-10021, ZBJ-09007, ZBJ-11002, ZBJ-10020, Raya Anmol, ZBJ-11030, ZBJ-08047, ZBJ-08051, ZBJ-06012 and Toria. The genotypes were sown at five locations i.e. Oilseed Research Station, Khanpur, District Rahim Yar Khan; Regional Agricultural Research Institute, Bahawalpur; Oilseeds Research sub-station, Piplan, District, Mianwali; Oilseeds Research Institute, Faisalabad and Vegetables & Oilseeds section, Ayub Agricultural Research Institute, Faisalabad. The experiment was conducted following randomized complete block design with 3 replications. Plot size of 4 rows of 6meter long with 45 cm row spacing was used. Experiments were sown at each site with recommended seed rate. Fertilizer NPK (Kg/ha) 75: 75:0 was applied and incorporated at the time of seed bed preparation. 1st irrigation was applied 30 days after emergence, 2nd at flowering stage, 3rd at silique formation and 4th at seed formation. Weed and pest control measure were applied whenever required. Seed yield per plot (grams per plot) was determined by harvesting and threshing of all 4 rows from each plot and converted into kg/ha. A combined analysis of variance over location was computed assuming replications and location effects as random and genotypes were considered as fixed variable (Steel and Torrie, 1980).

Statistical analysis:

A combined analysis of variance was used to evaluate the genotype-environment interaction. Whenever, the variance due to genotype-environment interaction was significant, the analysis was continued in order to estimate the stability parameters. The phenotypic stability under different environments was calculated by using Eberhart and Russell (1966) model.

$Y_{ij} = \mu_i + \beta_i I_j + \delta_{ij}$

Where; Y_{ij} = Genotype mean of ith genotypes at jth environments, μ_i = Mean of all genotypes over all environments, β_i = the regression coefficient of the ith genotypes on the environmental index, which measure the response of this genotype to varying environments, I_j = Environmental index, which is defined as the deviation of the mean of all genotypes at a given environment from the grand mean, and δ_{ij} = the deviation from regression of ith genotypes at jth environments. In Eberhart and Russell model, β_i (regression coefficient) is considered as parameter of response and S^2d_i as the parameter of stability (Khan *et al*., 1988; Yadav& Kumar, 1983 & 1978).

The stability parameters are given below.

1. Regression coefficient (b_i): This is a regression performance of each genotype in different locations calculating means over all the genotypes and estimated by following Singh and Chaudhary, (1979).
2. Mean square deviation from regression (S^2d_i): This was calculated for each genotype following Eberhart and Russell Model (1966). A genotype, which has high mean yield, regression coefficient (b_i) close to unity and deviation from regression (S^2d_i) near to zero, is defined as a stable genotype.

Results and Discussion

Mean performance

Differences in mean seed yield performance of 10 genotypes of *Brassica juncea* were significant at all locations indicating presence of significant amount of variation among the genotypes (Table 1). Out of all the tested genotypes, 6 genotypes given higher seed yield relative to overall mean value (1930 kg ha^{-1}) (Table 2). The mean seed yield (kg ha^{-1}) of these five locations, ranged from 1359 to 2532 kg ha^{-1}. Highest average seed yield was 2532 and 2370 kg ha^{-1} at Faisalabad and Khanpur respectively, followed by V & O, Agronomy (1738 kg ha^{-1}). Bahawalpur was the lowest yielding location with an average seed yield of 1359 kg ha^{-1}. The highest yielding genotype ZBJ-10021 on overall mean basis gave the highest yield at Faisalabad (3010 kg ha^{-1}) and Khanpur (2978kg ha^{-1}), closely followed by ZBJ-10020 (2855 kg ha^{-1}) at Khanpur. The highest seed yield of 3010 and 2978 kg ha^{-1} was obtained by ZBJ-10021 at Faisalabad and Khanpur locations respectively. The genotype ZBJ-10021 out yielded all others and produced 2301kg ha^{-1} seed yield followed by genotype ZBJ-09007 and ZBJ-11002 with seed yield of 2204 and 2167 kg ha^{-1}, respectively. The genotype Toria remained at the lowest and produced the seed yield of 1165 kg ha^{-1}.

Genotype × environment interactions

Pooled analysis of variance (ANOVA) indicated significant genotype × environment interaction (GEI) and showed the environmental influence on the performance of the genotypes (Table 1). The same has been reported by Ali *et al*. (2001); Mirza *et al*. (2002); Khan *et al*. (1988); Wani (1992); Aslam *et al.* (2015); Maqbool *et al.* (2015). Linear and non-linear are two components of genotype × environment interaction. Mirza *et al*. (2002) and Eberhart & Russell (1966) reported that these components are important for determination of differential genotypic response to different environmental conditions. Genotypic responses to the environmental changes were under genetic control (Ali *et al*., 2001; Mirza *et al*., 2002). The seed yield of studied ten *B. juncea* genotypes from five studied locations was pooled and combined analysis of variance was performed. Table-1 showed combined analysis of variance (ANOVA) revealed the significant differences between genotypes, locations and their interaction (G × E). Kirishnan *et al.* (1997);

Ravi *et al*. (1997); Dhillon *et al*. (1999); Wani (1992) and Ali *et al*. (2002) also reported significant G × E interaction for yield in mustard and Indian rapeseed. The significant G × E interaction (GEI) showed that seed yield ranking of genotypes was changed over the locations for their performance due to presence of environment interaction on yield performance. Thus genotypic stability parameters from seed yield were calculated for *B. juncea* genotypes. The regression coefficient (b_i) of *B. juncea* genotypes ranged from 0.399 to 1.433. The genotype ZBJ-10021 and ZBJ-11030 had the highest regression coefficient (b_i =1.433) followed by genotype Raya Anmol (b_i =1.333) and ZBJ-10020 (b_i =1.283). The regression coefficient more than unity (b_i>1.0), above average performance and minimum deviations from regression indicated that these entries are suitable for favorable environments.

The genotypes ZBJ-08047 (b_i = 1.025) and ZBJ-09007 (b_i = 0.932) had regression coefficient near to unity and least deviation from regression (S^2d_i = 0.165 and 0.099) respectively, hence suitable for wider range of environments. Similar results were previously mentioned by Ali *et al*. (2002). Table 2 indicated that genotypes ZBJ-10020 and ZBJ-11030 possessed significant coefficients (b_i) and mean square deviation from regression (S^2d_i) are not significantly deviating from 1 hence considered highly responsive genotypes, therefore suitable for favorable environments and the performance of these genotypes to environmental changes is predictable and feasible for seed yield studied (Singh & Chaudhry, 1979).

The seed yield in *Brassica juncea* grown in Pakistan is significantly influenced by genotype × environment interaction (GEI) of the total variation. According to the results based on mean seed yield, coefficient of regression (b_i) and deviation from regression (S^2d_i), it is concluded that ZBJ-09007 genotype showed well adaptability in all the environments of Punjab.

Table 1.Combined Analysis of Variance for seed yield (kg ha^{-1}) of 10 Brassica juncea genotypes at 5 locations

Source	DF	Mean Square	F. value
Loc	4	9.33402	68.18**
Error Loc x Rep	10	0.13690	
Gen	9	1.79248	
Loc x Gen	36	0.23705	36.54**
Error Loc x Rep x Gen	90	0.04906	4.83**
Total	149		

** Significant differences at 1 percent (P < 0.01)

Table 2. Mean Performance of 10 *B. juncea* genotypes for seed yield (kg ha^{-1}) and stability analysis from 5 locations during 2013-14 in the Punjab.

		Results of Zonal Varietal Trials (Yield in kg ha^{-1})								
RANK	**Lines/Variety**	**F/Abad**	**K/pur**	**BWP**	**Piplan**	**V & O**	**Avg.**	**Mean**	**b_i**	**S^2d_i**
1	ZBJ-10021	3010	2978	1296	2000	2222	2301	2301	1.433	0.192
2	ZBJ-09007	2612	2577	1404	2420	1821	2167	2204	0.932	0.099
3	ZBJ-11002	2491	2608	1528	2296	2099	2204	2.167	0.811	0.21
4	ZBJ-10020	2675	2855	1512	1704	1975	2144	2144	1.283*	0.019
5	Raya Anmol	2483	2670	1543	1358	1852	1981	1981	1.333	0.122
6	ZBJ-11030	2702	2701	1188	1383	1790	1953	1952	1.433*	0.075
7	ZBJ-08047	2286	2377	1528	1531	1543	1853	1853	1.025	0.165
9	ZBJ-08051	2638	1944	1358	1259	1605	1761	1773	0.570	0.304
8	ZBJ-06012	2681	1759	1049	1556	1821	1773	1761	0.781	0.154
10	TORIA	1742	1235	1188	1012	0648	1165	1165	0.399	0.32-5
	Average	3010	2978	1296	2000	2222	2301	1930		
	LSD 5%	**143**	**247**	**215**	**92**	**229**	**246**			
	CV%	**20.57**	**5.66**	**8.52**	**4.81**	**6.78**				

References

Ahmad, J., M.H. Choudhery, S. Salahuddin and M.A. Ali. (1996). Stability for grain yield in wheat. *Pak. J. Bot.,* 28: 61-65.

Ali, N., F. Javidfar and A.A. Attry. (2002). Staility analysis of seed yield in winter type rapeseed *(Brassica napus*) varieties. *Pak. J. Bot.,* 34: 151-155.

Ali, N., J. Fazad and M.Y. Mirza. (2003). Selection of stable rapeseed (*Brassica napus* L.) genotypes through regression analysis. *Pak. J. Bot.,* 35: 175 -180.

Ali, N., M.S. Nawaz, M.Y. Mirza and G.R. Hazara. (2001). Stability analysis for pod yield in groundnut (*Arachis hypogaea*L.). *Pak. J. Bot.,* 33: 191-196.

Aslam, M., M.A. Maqbool, M. Yaseen, Q.U. Zaman. (2015). AMMI Biplot analysis for comparative evaluation of maize genotypes under different saline environments. *Pak. J. Agric. Sci.,* 52: 339 -347.

Dhillon, S.S., K. Sing and K.S. Bar. (1999). Stability analysis of elite strain in Indian mustard. Proc. 10th Intl. Rapeseed Congress held at Canberra, Aust.

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

Escobar, M., M. Berti, I .Matus, M .Tapia and B. Johnson. (2011). Genotype x Environment inter action in canola (*Brassica napus* L.) seed yield in Chile. *Chilean J. Agric. Res.,* 71: 175-186.

Finlay, K.W. and G.N. Wilkinson. (1963). The analysis of adaptation in plant breeding programme. *Aust. J. Agric. Res.,* 14: 742-754.

Freeman, G.H. and J.M. Perkins. (1971). Environmental and genotype-environmental components of variability VIII. Relations between genotypes grown in different environments and measures of these environments. *Heredity.* 27: 15-23.

Hebert, Y., C. Plomion and N. Harzic. (1995). Genotypic x environment interaction for root traits in maize as analysed with factorial regression models. *Euphytica,* 81: 85-92.

Hussain, S.M., B.K. Sarma and V. Mahajan. (1996). Stability analysis of seed yield in rapeseed mustard under Nagaland conditions. J. Hill Res. 9: 161-162.

Javid, F., M.H. Alemkhomaram, H.A. Oghan and S. Azizinia. (2004). Yield stability analysis of winter canola (*Brassica napus* L.) genotypes. *Seed and Plant Imp. J.,* 20: 315-328.

Khan, A., M. Rahim, N.J. Maik and A. Khan. (1998). Phenotypic stability of pod yield and related characters in bunch type peanut genotypes. *Sarhad. J. Agric. Res.,* 14: 441-446.

Khan, I.A., B.A. Malik and M. Bashir. (1988). Investigation of genotype x environments interaction for seed yield in chickpea. *Pak. J. Bot.,* 20: 201-204.

Maqbool, M.A., M. Aslam, H. Ali, T.M. Shah, B.M. Atta. (2015). GGE biplot analysis based selection of superior chickpea (*Cicer arietinum* L.) inbred lines under variable water environments. *Pak. J. Bot.,* 47: 1901-1908.

Mirza, M.Y., A. Qayyum, A. Naazar, M.S. Nawaz and S.S. Mehdi. (2002). Stability analysis for yield in 22 soybean. Pak. J. Agric. Sci., (In press).

Rashid, A., G.R. Hazara and N. Javed. (2000). Genotype x environmental interaction and stability analysis in mustard (Brassica juncea). Proc. 3rd International Crop Sciences Congress, 17-22 August, 2000, Hamburg, Germany.

Ravi, K., S.P. Sinhamahapatra and M. Subrata. (1997). Genotype x environment interaction in relation to combining ability in Indian mustard. *Indian J. Gen. Plant Breed.,* 57: 274-279.

Shulka, G.K. (1972). Some statistical aspects of partitioning genotype-environment components of variability. *Heredity,* 29: 237-245.

Singh, R.K. and B.D. Chaudhry. (1979). Biometrical methods in quantitative genetic analysis. Kalyani Publ., New Delhi.

Steel R.G.D. and J.H. Torrie. (1980). Principles and procedures of statistics, 2nd Ed. McGraw Hill Book Co. Inc. New York.

Wani, S.A. (1992). Genotype x environment interaction for yield and its components in Indian mustard. *Adv. Plant Sci.,* 5: 421-425.

Yadav, I.S. and D. Kuma. (1983). Stability for seed boldness in black gram. *Madras Agric. J.,* 70: 193-194.

Yadav, T.P. and P. Kumar. (1978). Stability analysis for pod yield and maturity in bunch group of groundnut. *Indian J. Agric. Res.,* 12: 1-4.

Yan, W., M. Kang, S. Woods, P. Cornelius. (2007). G x E biplot vs. AMMI analysis of genotype-by -environment data. *Crop Sci.,* 47: 643-635.

Yao, J.B. and C.K. Xu. (1994). A study on adaptability and yield stability of rapeseed varieties in Huainan region. *Oil crops of China,* 16: 21-24.