Acclimatization of Mustard (*Brassica juncea* L.) Genotypes under Different Agro-Climatic Zones of Punjab Province, Pakistan

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Abstract: The study was performed for the evaluation of promising mustard genotypes regarding seed yield and adaptability in different agro-climatic areas of Punjab province, Pakistan. Eight genotypes with three replications were tested at different locations under Randomized Complete Block Design. Data were recorded for seed yield Kgha^{-1} for each genotype. Analysis of variance revealed that there are significant differences ($P \leq 0.05$) among these genotypes. Further data were subjected to Biplot analyzes, which exposed that the total sum of squares of variation for the environment (E), genotype (G) and genotype into environment interaction (G×E) was 92.5%, 1.2%, and 6.3% respectively. Genotype one performed well for yield and adaptability at all eight locations while others genotypes showed location specific performance. So, genotype one should be use in further breeding program for the development of high yielding and stable mustard cultivar.
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Key words: Mustard, Biplot analysis, Genotype-environment interaction, Seed yield, Canola.
Abbreviations: WUE, water use efficiency; PC, principal component; ANOVA, analysis of variance; RCBD, Randomized complete block design; GE, genotype, and environment interaction.

Introduction

Brassica species are the major source of vegetable oil in most countries. Mustard comes under the umbrella of *Brassicaceae* family. This family consists of 338 genera and 3709 species (Warwick *et al*., 2006). There are diploid and allotetraploid species of brassica. Allotetraploid developed by interspecific hybridization of diploid species that are Mustard (*Brassica juncea*; AABB, 2n=36), Rapeseed (*Brassica napus*; AACC, 2n=38) and *Brassica carinata* (BBCC, 2n=34). Diploid Brassica species are *Brassica rapa* (AA, 2n=20), Black mustard (*Brassica nigra*; BB, 2n=16) and *Brassica oleracea* (CC, 2n=18). Brassica juncea (L.) is well adapted to hot and dry conditions than the presently grown canola species, *Brassica napus*, and *Brassica rapa*. Mustard is more tolerant to drought, heat and is resistant to blackleg fungus, it has vigorous seedling growth and covers ground rapidly than rapeseed (Wood et al.1991, Burton et al.1999).

The production of edible oil in Pakistan is insufficient. Low production of edible oil in Pakistan is due to the non-replacement of low yielding genotypes with high yielding improved ones. The Total availability and import of edible oil were 2,335000 and 1,789000 tons respectively, and the production of rapeseed/mustard was189,000 tons which is lesser in contrast with other countries of the world (Economic Survey of Pakistan 2014-15). Past studies revealed that production of rapeseed/mustard can be raised by introducing and adapting the recently developed and high potential genotypes (Anjum *et al.,* 2005), (Ozer and Oral, 1997), (khan et al, 1998) and (Sharma and Manchanda 1997). The increment in edible oil by introduction and adaptation of high yielding and newly developed varieties of rapeseed/mustard (Ozer & Oral, 1997; Sharma & Manchanda, 1997; Khan et al., 1998). Canola (*Brassica juncea* L.) recently introduced oil crop developed from mustard through conventional breeding. Canola is considered as best edible oils for human because its seed contains (40-45%) of saturated fat and (36-40%) protein (Alberta Agriculture, 1984. Oil and seed protein content were more affected by environmental conditions as compared to genotypic effects, while the reverse in case of glucosinolate concentration. Oil quantity in canola is mainly influenced by temperature fluctuations (Mustafa *et al.,* 2014).

Canola oil and meal are now readily acceptable as alternatives to soybean oil and meal (Amin & Khalil, 2005; Mohammad *et al.,* 2007). In addition to oil production, canola provides high-quality forage because of its low fiber and high protein content in its stem and leaves (Wiedenhoeft & Barton, 1994). Canola (*Brassica juncea L.*) is adapted as a major crop in many countries like Canada, Australia, China, USA, due to its large national economic benefits. It is comparable to one of those crops having high WUE and can tolerate drought (Howell, 2000) and salinity (A-Thabet, 2003). Previous research has shown that it can be grown as a winter annual like wheat with profit return equal or more than wheat (Raymer *et al.,* 1996). This study was pertained to test the performance of different mustard lines for adaptability and seed yield in different ecological zones.

Materials and Methods

The present study was conducted for the evaluation of yield performance of advance mustard lines developed at Oilseeds Research Institute, Faisalabad, Pakistan under different agro-climatic conditions. There were eight genotypes having different morphological traits i.e; 9CBJ004, KJ-148, BRJ-9070, RBJ-08015, BRJ-9074, KJ-209 and ZBJ-08051 along with Khanpur Raya as check variety tested at eight locations with the different agro-climatic conditions, including Faisalabad, Bahawalpur, Khanpur, Piplan, Chakwal, Fateh Jang, Karor and Bhakkar.

An experiment was conducted in 2013-14 during the winter season (October to mid-April). Randomized Complete Block Design (RCBD) was used with three replications. Plot size was maintained 5×1.35 m, row spacing 45 cm and plant to plant distance was 15 cm. Each of nitrogen and phosphorus fertilizer were applied at the rate of 75 kg/ha along with the same agronomical practices at all locations like number of irrigations, the use of pesticide etc. following parameters contributing to yield were measured as days to 50% flowering, plant height, number of seeds/silique, number of primary or secondary branches and seed yield kg/ha. Ten plants from each plot were taken randomly at physiological maturity to measure plant height. Days to 50% flowering was completed from sowing to 50% flowering. Data on seed yield kgha^{-1} of mustard lines were recorded from 8 locations and were subjected to analysis of variance Analysis showed highly significant differences for yield among genotypes, the means for seed yield were further separated and compared by using the least significant difference (LSD) test at 5% level of probability. For the comparison of seed yield Biplot analysis was also done according to Yan *et al*., (2000).

Results and Discussion

Demonstration of results and discussion involved two steps; first step presents the outcome of analysis of variance, representing total sum of squares for G, E and G×E interaction in percentage for under testing regions; the second step represents yield performance and stability of genotypes which depends on interrelation of genotypes and environments, average performance of genotypes in different environments and their suitability depending upon yield performance in specific region and across the region, comparison of genotypes for identification of their best-suited environment.

Table 1. List of Genotypes and Locations with average yield Kgha^{-1}

Sr. No.	Trial	Faisalabad	Bahawalpur	Khanpur	Bhakkar	Chakwal	Fateh jang	Piplan	Karor
G1	Khanpur Raya	1865	3423	2513	2035	1178	830	1576	1534
G2	9CBJ004	2488	2682	2413	2073	1384	1013	1319	1294
G3	KJ-148	1797	3699	2614	1737	1093	1158	1305	1073
G4	BRJ-9070	1897	3045	2801	1570	1040	746	1406	1457
G5	RBJ-08015	1872	3287	2627	2032	938	948	1123	1182
G6	BRJ-9074	1578	3231	2578	1739	902	854	1430	1155
G7	KJ-209	1893	2726	2599	2071	1013	914	1154	931
G8	ZBJ-08051	2061	3005	2420	2061	470	851	977	1071

The total sum of squares of Genotype, Environment, and Genotype into Environment interactions were used as an index of variability components to seed yield. Genotype or Genotype into Environment interactions variability determines that how genotypes perform over diverse environments. Past study in various crops revealed that contribution of environmental variation is larger in total variation if the heritability of traits is low, if the heritability is high, traits will be less influenced by environment (Ethridge and Hequet, 2000; Kerby *et al.,* 2000; Epinat-Le *et al.,* 2001).

ANOVA showed the interaction of genotype and environment was significant (Table 2). The differences between evaluated genotypes, location, environment, and the genotype × environment interaction are shown in Figure 1. The graph presents 74 percent data variation as PC1 shown 50.9% and PC2 23.1%. Biplot analysis showed the performance of eight genotypes in various location, it was used to find the best genotype for each location (Figure 1), the probable relationship between the locations was studied to grade the regions on diversity and give the position of the genotypes in superior locations (Figure 2).

The (PC1) horizontal axis in bi-plot analysis represents the main effects due to the genotypes and (PC2) vertical axis indicate the G×E interaction, which is considered as the main principle for instability of genotypes (Yan, 2002). The line which passes from the origin of the coordinate to the location's mean is called the mean axis of locations. The genotype gives higher production, which exists on axis in positive side or vice versa. The organizational pattern of genotypes for stability is accordingly G_4, G_5, G_1 and G_6 were highly stable than other genotypes. Generally, genotypes falling near to the origin were known as more stable and were less effected by environmental changes and were ideal genotypes while genotypes standing close to the positive end of the mean axis of environments and that axis should be shorter in length vertically. On the basis of this particular evidence, G_1 was best and can be helpful for the purpose of evaluation of other genotypes; those genotypes were appropriate more which present closely near to ideal (higher in yield and stability). Vectors drawn for genotype or environment are useful to visualize the particular interaction of G×E (Yan and Tinker, 2006). If the angle between genotype vector and the environment is less than 90°, genotype would perform better for that specific environment and vice versa; if the angle is =90° performance would be near to mean, which is demonstrated by a property of Bi-plot analysis (Gabriel, 1971).

Table 2. Analysis of Variance showing total variation percentage

Source	DF	SS	MS		Total variation explained (%)	GxE explained (%)	Cumulative (%)
Total	191	114700758	-				
Environment(E)	7	106074646	15153521	**	92.5		
Reps within E	16	16178	1011				
Genotype(G)	7	1321958	188851	**	1.2		
GxE	49	7232593	147604	**	6.3		
IPCA1	14	3677880	282915	**		50.9	50.9
IPCA2	12	1668561	151687	*		23.1	73.9
IPCA3	10	778515	86502			10.8	84.7
IPCA4	8	556374	79482			7.7	92.4
IPCA residual	10	255212.4	25521				
Residual	112	55383	494				

* Significant; ** highly significant at 5% level of Probability

The organization of the genotype according to the yield performance on biplot was as follow; Generally G_1 was overall better because it has less variance followed by G_3 and specifically G_3 was recommended for BPR and KPR; G_1 and G_4 for PPL, KRR and CKW; G_2 followed by G_7 for FSD and BKR; G_4 and G_5 were more stable than all other genotypes because both lie near to origin and were adaptive to KRR, FTJ, and CKW but average yield was equivalent to mean of all genotypes whereas G_1 and G_3 are stable and high yielding so only G_1 was recommended for general cultivation in all under test locations and G_3 specifically for BPR and KPR. G_2 and G_8 were poor performings at all locations except G_2 in FSD and BKR. G_6 was adaptive to KPR, PPL and KRR but yield performance was poor.

Conclusion

The breeder should develop varieties which are more adaptive under diverse environment, climate resilient and high yielding to combat the current scenario of climate change. Bi-plot analysis is the best approach to identify the stable and high yielding genotypes under multi-environments.

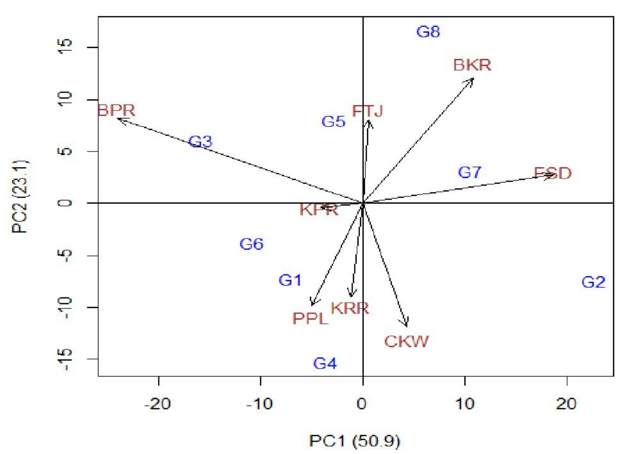

Fig. 1 Interaction of Genotype and Environment

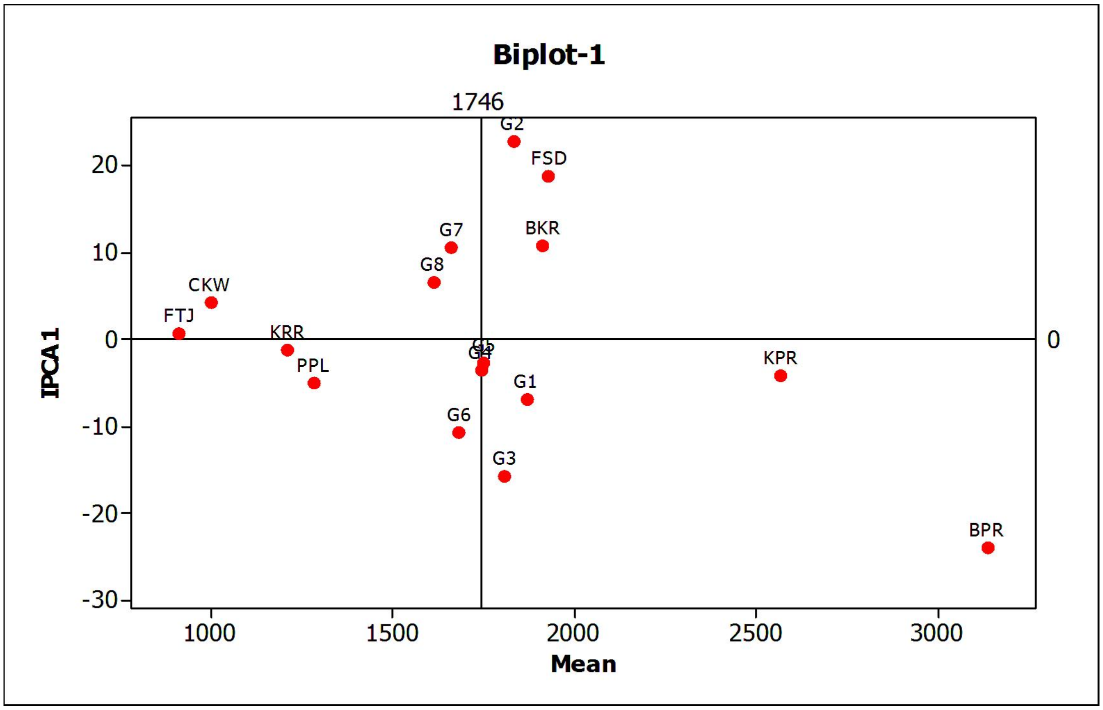

Fig. 2 Genotypes and their Environments on the basis of average yield and stability.

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