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Genotype X Environment Interaction and Stability Analysis in Mustard

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Abstract: Genotype x environment interaction limit the effectiveness of selection when selection is based only on mean yields. This study evaluated eight mustard (*B. juncea*) cultivars and breeding lines of Oilseed Research Programme at ten different agro-ecological zones during winter 1997-98 and 1998-99. The significant GxL interaction caused difficulty in identifying superior yielding mustard genotype. Therefore, stability parameters in addition to mean seed yield over environments were calculated. The analysis of variance indicated that heterogeneity of regressions was highly significant ($P<0.01$). The overall yield performance of the KS-74, CV-3 and BARD-1 genotypes was superior. Genotypes KS-74 and CV-3 had b-values near to one and low deviations from regression indicating relatively stable performance over environments. The lowest b-value of BARD-1 indicated that it performed relatively better in low yielding environments and less well adapted to favorable environments. The result of this investigation demonstrated that production response index (regression coefficient) and other stability parameters are suitable means of selecting cultivars that are stable, high yielding and responsive. It is Further illustrated that the regression coefficient is the most useful stability statistics, which can be applied for the selection of brassica cultivars adapted to wide range of environments or adapted to restricted environments.

Key words: Mustard, stability, genotype, environment

Introduction

In plant breeding programme, many potential genotypes are usually evaluated in different environments (locations and years) before selecting certain desirable genotypes. For quantitative traits such as seed yield, the relative performance of different genotypes often varies from one environment to another i.e., genotype-environment (GE) interaction exists. Such GE interaction results in change the relative rank of genotypes or change in the magnitudes of differences between genotypes from one environment to another. Changes in ranking make it difficult to the plant breeders to decide which genotypes should be selected. A number of statistics have been proposed to measure the genotypic stability, however, no single method can adequately explain cultivars performance across environment.

Lin *et al.* (1986) has established three major concepts of stability. Type 1 stability (genotype mean square$=S^2$I and genotypic coefficient of variation$=$CVi) measure the variation within a genotype across environment. This stability parameters are related to homeostasis and has been associated with low yield (Becker, 1981; Lin *et al.*, 1986). Type 2 stability (ecovalence$=W^2$I and Shukla's stability variance$=\sigma^2$I) which basically measure the deviation of the individual genotypes from the location means of all genotypes in test. Type 3 (regression slope$=$bi) stability is calculated by the residual mean square from the regression of individual cultivar yields on an environmental index (Eberthart and Russell, 1966). In this method, slope of regression provided an indication of regions of adaptability as well as stability. It also indicates the cultivar response to the predictable component of the environment.

Rapeseed and mustard cultivars are highly responsive to the changing environment due to it long growing season and in-determinant growth and development habit. Mustard varieties are quite high yielding under appropriate environmental conditions. It is therefore, necessary to breed cultivars, which adapted to both irrigated and rainfed conditions of Pakistan and produce stable seed yield.

Therefore, objective of this study was to find out an integrated approach to select suitable genotypes of mustard, which widely adapted to the climatic conditions of Pakistan.

Materials and Methods

Eight mustard (*B. juncea*) cultivars and breeding lines of Oilseeds Research Programme were evaluated in National Uniform Mustard Yield Trials (NUMYT) during rabi 1997-98 and 1998-99. These trials were conducted at ten locations within the provinces of Punjab, NWFP and Sindh in which the climatic conditions quite different from each other's. The experiments were laid according to Randomized Complete Block Design. A plot size of 10 m^2 (6 rows, 5 meters long and 30 cm apart) was used.

Fertilizer was applied at the time of planting, the rate of 90 N and 60 P_2O_5 kg per hectare. Irrigation, weed and pest control measures were provided whenever required.

Statistical analysis: Crop was harvested at physiological maturity and data on seed yield recorded. The analysis of variance combine over locations and years was carried out to detect the differences among genotypes, locations and genotype-environment interaction using the statistical package Mstat-C. Fixed effects model was assumed for the analysis of variance. In addition, the total genotype x environment interaction sum of square was partitioned into the heterogeneity among regression and remainder source (Perkins and Jinks, 1968).

Stability parameters as suggested by Eberthart and Russell (1966) were calculated. In this, entry x locations means were regressed on an environmental index, and the resultant b-values for each entry were considered as a measure of response to environments. The environmental index in this case was the deviation of the location means from the grand mean. Mean square of deviation from regression (S^2di) for each genotype was calculated. The stability parameters "r^2, σ^2I and CVi, were also calculated. To visually assess general adaptability, the entry mean and maximum yield from each location were plotted against location means (Lin and Binns, 1988).

Results and Discussion

Mean genotype yields ranged from 1.181 to 1.426 t ha^{-1}. The highest yielding cultivars were KS-74, CV-3 and BARD-1 (Table 1). The location effects were significant for the seed yield, while the year effects were non-significant. This indicated that environmental conditions at the locations were fluctuating and persist in both years. The variability among the locations may be attributed by the differences in soil type; temperature and rain fall during the growing season whereas pattern of environmental changes was same from 1997-98 to 1998-99. Genotype-location interaction mean squares were significant ($P<0.01$). The significant G x L effects demonstrated that genotypes responded differently to the variation in environmental conditions of locations. The significant interaction of genotypes and locations indicated the necessity of testing at multiple locations for divergent geographical regions.

The significant GxL interaction caused difficulty in identifying superior yielding mustard genotype. Therefore, stability parameters in addition to mean seed yield over environments were calculated. The analysis of variance indicated that heterogeneity of

Table 1: Mean yield and stability parameter estimates (bi, S^2di, r^2, σ^2I, CVi for eight mustard cultivars and breeding lines grown at ten locations for 2 years

Genotypes	Mean yield(t ha^{-1})	bi	S^2di	r^2 (%)	σ^2I	Cvi (%)
KS-74	1.416	1.01	0.025	76.1	0.024	23.2
CV-2	1.270	1.21	0.041	69.8	0.027	29.9
CV-3	1.307	0.99	0.029	72.8	0.035	25.4
CV-4	1.181	0.83	0.004	94.6	0.013	23.4
CV-5	1.138	1.18	0.049	65.3	0.039	34.3
CV-6	1.278	1.10	0.021	80.6	0.012	26.7
CV-7	1.212	0.90	0.014	82.8	0.029	24.5
BARD-1	1.371	0.78	0.033	64.3	0.072	22.8

regressions was highly significant ($P<0.01$). Therefore, there were significant differences among the b-values of genotypes.

The ideal genotype as proposed by Eberthart and Russell (1966) would have a high mean performance over a range of environments, a regression coefficient of one and deviation mean square from regression of zero. Genotypes with regression coefficient greater tan 1.0 would be adapted to more favorable environment, while those with coefficient less than 1.0 would be relatively better adapted to less favorable growing conditions. In the stability analysis, the regression of genotype mean yield on the environmental index resulted in regression coefficients ranging from 0.78 to 1.21. This large variation in regression values indicated large differences in genotype responses to different environments. The overall yield performance of the KS-74, CV-3 and BARD-1 genotypes was superior. Genotypes KS-74 and CV-3 had b-values near to one and low deviations from regression indicating relatively stable performance over environments. Ali *et al.* (2001) observed same findings that two top yielder genotypes BM-28 and ICGV-86550 had slop around unity. The lowest b-value of BARD-1 indicated that its performance was relatively better in low yielding environments and less well adapted to favorable environments. The highest b-value of CV-2 indicated that it was highly responsive to environment but had low seed yield due to poor performance in low yielding environments. The breeding lines "KS-74 and CV-3" were well adapted to the complete range of productivity levels giving superior yields in low- as well a high-yielding environments.

CVi is the variance of genotypes across environments, weighted by the cultivar mean and it reflects homeostasis or buffering ability of cultivars. The low CVi values indicated that KS-74 and BARD-1 had the most consistent yield, therefore had relatively better buffering ability. The high CVi value indicated that CV-5 had least consistent yields. Becker (1981) and Lin *et al.* (1986) have argued that well-buffered cultivars are generally low yielding. CVi provide no information about the response over a range of environment, therefore, probably most useful over restricted geographical ranges. However, selection of well responsive, high yielding cultivars with good Type 1 stability is possible, KS-74 and BARD-1 may be example of such cultivar.

The σ^2 value for BARD-1 indicated that its yield performance was not parallel to the other cultivars under test and was therefore, considered to be unstable. A very low σ^2I value of CV-6 indicated that its yield performance was parallel to the means of the other cultivars under test and was stable according to the Shukla (1972) and Shukla *et al.* (1972) definition of stability. Becker (1981) defined cultivars with low ecovalence values (Wricke, 1964) are agronomically desirable. Since ecovalence and σ^2I values are equivalent (Lin *et al.*, 1986) for the purpose of ranking. Becker's (1981) arguments may be apply to σ^2I values as well. However, Lin *et al.* (1986) criticized σ^2I because cultivars are only stable relative to the particular sample of cultivars used in the test. If all the cultivars used in the test are not representative of those grown in the region, then the relative nature of σ^2I as a stability parameter can be misleading.

The result of this investigation demonstrated that production response index (regression coefficient) and other stability parameters are suitable means of selecting cultivars that are stable, high yielding and responsive. It is Further illustrated that the regression coefficient is the most useful stability statistics which can be applied for the selection of brassica cultivars adapted to wide range of environments or adapted to restricted environments.

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