Chapter-II

Review of Literature
Several workers have studied "A study on stability for yield and yield contributing characters in barley (Hordeum vulgare L.) under Bundelkhand situation." In this chapter, the literature pertaining to different aspects of the problems under study has been reviewed.

GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE

The barley is cultivated under varied agro climatic conditions. There is a need to isolate, identify and characterize the varieties suitable under varied agro climatic and fertilizer conditions. This will be helpful in selection of new parent and cultivated varieties suitable under different levels of fertilizer and irrigation for breeding programme of hybridization for the crop improvement.

Yadav et al., (1991) obtained information on genetic variance and heritability derived from data on 6 yield components in 8 diverse and elite barley genotypes and their F₁ and F₂ generations grown at Deoria in rabi 1979-80, cv. Ratna carried a high frequency of dominant genes for tillers per plant, ear length and grain yield per plant and cv. Jyoti for spike lets per ear and 1000 grain weight. Heritability in the F₁’s and F₂’s was high for tillers per plant and grain per ear.

Kaeppler et al., (1991) conducted research to determine the inheritance and to examine maternal quality factor in malting barley. Heritability of alpha amylase activity was estimated by measuring activities of seed from field growths of parents and progeny. The heritability of alpha
amylose activity on an \( F_2 \) plant basis ranged from 0.37 to 0.65, while on an \( F_5 \) line basis it ranged from 0.39 to 0.74.

Yadav (1993) information on genetic variance, genotypic correlation and path analysis was derived from data on growth parameters in 25 elite varieties of barley raised under non saline and saline irrigated conditions during rabi season of 1988-90 in Haryana. Tillers/plant, spike length and 1000-grain weight showed low genetic variance as well as genotypic coefficient of variation. Heritability was lower under saline than non saline condition for all the traits except 1000-grain weight. Genetic correlation and path coefficient analysis were modified under saline stress.

Sharma and Maloo (1994) obtained information on genotypic and phenotypic variability derived from data and yield related traits in 36 \( F_2 \) hybrids and their 9 parents. Variability was high for grain yield, ear/plant and tillers/plant.

Nadziak et al., (1994) tests 94 varieties of the 6 rowed type and 53 of the 2 rowed type during 1987-90. The degree of genetic variability was determined. Heritability estimates were high for ear length, hardiness, plant height and grain yield in 6 rowed types and for lodging hardiness, plant height and grain yield in 2 rowed types.

Park et al., (1994) evaluated 137 accessions of wheat and barley at Research institute of Suwon during 1988-89. The heritability estimates for starch content was 30 per cent.

Lu et al., (1995) conducted trials with 5 cultivars of two - rowed barley. Heritability of various characteristics with seed yield/plant was low showing that the choice of a single character in selection is inefficient. The number of ears/plant was the most effective character for selection. The
most effective combination of characters for high yielding selection was number of ears/plant, number of seeds per ear and seed yield.

Kudla et al., (1995) studied of F₂ hybrids from reciprocal crosses between the induced mutant M-96, with many ears per plant and the strain B-81, with many grains per ear, non additive gene action played the predominant role in the inheritance of grain yield per plant and plant height. Additive genes were more important in the inheritance of grain number per ear, ear number per plant and 1000 grain weight. Heritability estimates were highest for plant height and lowest for number of ears per plant.

Sajeda Begum et al., (1997) reported that the grain yield had the highest phenotypic and genotypic coefficient of variation, followed by number of fertile tillers. All the traits studied possessed high heritability values, the highest being for grain yield. Genetic advance was high for grain yield followed by number of fertile tillers and grain size.

El-Hennawy (1997) conducted two field experiments to estimate the genetic coefficient of variation, heritability and genetic advance in 6 yield components measured from 20 barley cultivars (8 Local and 12 German cultivars). Path analysis was used to assess the relative importance of plant characters contributing to yield. The results indicated that the highest genetic coefficient of variation was obtained for grains/spike and grain yield per plant while lowest values were recorded for plant height and 100-kernel weight. The heritability estimates ranged from 29.03 percent for harvest index to 71.30 percent for per spike. Expected genetic advance with selection of the highest 5 percent, expressed as a percentage of the mean, ranged from 11.62 percent for plant height to 58.31 percent for grains per spike.
Martinez et al. (1998) reported the broad sense heritability for heading data ranged from 42 to 86 percent values obtained for grain yield 12 to 27 percent were more consistent among broad sense than narrow sense estimates genetic advance estimates were low due to lack of additive variance.

Leebu Babu et al., (1998) studied on genetic variability among 56 malting barley genotypes (comprising 23-2-rowed barley) for 16 quality and yield components. Seeds/spike, spikes/m², tillers/m², 1000-grain weight and seed yield/plot exhibited high heritability estimates coupled with high estimates of genetic advance. This implied the presence of adequate variability among genotype for further improvement based on additive gene action. Days to 50 percent flowering and days to maturity had low heritability.

Vimal and Vishwakarma (1998) observed that broad sense heritability ranged from 3.9 (days to maturity) to 967.8 percent (grain yield/plot) high heritability coupled with high genetic advance was noted for tillers/plant, spike length, spikelets/spike and grain yield/plant.

Sinha et al., (1999) studied on two crosses of barley namely BR 31x BM and K 69 x Ratna, in Bihar, India. In BR 31 x BM 4, high estimates of various heritabilities and intermediate genetic advance were recorded for days to heading, heritability were high but genetic advance as percolage of mean was low for grain yield per plant in K 69 x Ratna, medium to high estimates of various heritabilities were associated with high estimates of genetic advance for grain yield per plant. The heritabilities for tillers per plant, spike length, grains per spike and 1000 grain weight were low to intermediate.
Ram Kishore et al., (2000) observed that high estimates of phenotypic and genetic coefficient of variability were obtained for plant height, flag leaf length, number of grains/ear and grain yield/plant. High estimates of heritability coupled with high genetic advance were recorded for plant height, number of tillers/plant, flag leaf length and ear length.

Pilania; (2005) information on genetic variance, genotypic correlation and path analysis was derived from data on growth parameters in 30 varieties of barley. Tillers/plant, spike length and 1000-grain weight showed low genetic variance as well as genotypic coefficient of variation. Heritability was lower under saline than non saline condition for all the traits except 1000-grain weight. Genetic correlation and path coefficient analysis were modified under saline stress.

Dhama (2007) estimated the genetic coefficient of variation, heritability and genetic advance in 7 yield components measured from 25 barley cultivars. Path analysis was used to assess the relative importance of plant characters contributing to yield. The results indicated that the highest genetic coefficient of variation was obtained for grains per spike and grain yield per plant while lowest values were recorded for plant height and 100-seed weight. The heritability estimates ranged from 30.55 percent for harvest index to 69.66 percent for per spike. Expected genetic advance with selection of the highest 5 percent, expressed as a percentage of the mean, ranged from 10.89 percent for plant height to 60.24 percent for grains/spike.
CORRELATION COEFFICIENTS

The results of correlation analysis were presented by the Khodzhakulu (1980) for yield and 7 related characters in two varieties. Yield was closely related with number of ear-bearing tillers/m², 1000-grain weight and number of grains/ear. Correlation analysis results presented between yield components, the coefficient of correlation varied according to environmental conditions and agronomic practices but were successfully used as the basis for selecting for high yield grain set and tiller number.

Merskow et al. (1985) suggested that analysis of data on yield and 7 related characters in 6 F₂ hybrids, grain number/ear was correlated with grain weight/ear (r=0.65) and ear length (r=0.48) while plant height was correlated with ear length (r=0.54) and number of fertile tillers (r=0.32). It is thought that grain number/ear is a promising indirect character for use in selecting for a grain yield in F₂ population.

Singh (1987) studied that the nature of direct and indirect effects of the major yield characters in hull less barley by using path analysis. In general genotypic correlation was higher than the phenotypic correlation under all the three irrigated, rainfed and late sown cropping conditions. Grain yield exhibited positive correlation with number of ears per plant and 1000-grain weight, negative association was observed with plant height and ear length.

Singh and Singh (1990) studied grain yield was positively correlated with length of flag leaf, number of internodes per plant and number of ears per plant under rainfed and irrigated conditions and with stem length under rainfed conditions only.
Lin and Yu (1990) analyzed beta amylase activity and malt diastatic activity (ability to produce maltose from starch using its own diastase (alpha glucosidase) in mature seeds of 10 two rowed barley cultivars and 10 F2 hybrids which indicated that beta amylase activity was significantly correlated with malt diastatic activity ($r=0.991$). Alpha amylase activity was correlated with malt diastatic activity ($r=0.50$). Malt diastatic activity may be predicted by testing beta amylase activity.

Hadjichristodoulou-A (1991) conducted a field experiment in 1988-89 upto 65 barley genotypes were grown at 20 different Mediterranean sites with annual precipitation of 236-500 mm. It is concluded that optimum plant height under dry land conditions is about 100 cm, consistently high yielding cultivars were among the most stable in height, plant height was positively correlated with grain yield, straw/ yield and total plant dry matter in most experiments.

Dolicki (1992) conducted the experiment at various sites in the Beskide foothills over 5 years. Agronomic traits were investigated in 86-2 rowed winter cultivars of barley, generally tillering, ear length, 1000-grain weight were better in two rowed barley cultivars. For two rowed cultivars and strains, the weight of grains/ear was correlated with seed number/ear ($r=0.549$) and 0.508 while for multi rowed cultivars the weight of grains/ear was correlated with seed number/ear ($r=0.765$) and 1000-grain weight ($r=0.465$). Relation among other traits was not significant. The best over wintering multi rowed cultivars show lower seed weight/ear and seed weight/plot as well as lodging tendency. Local high yielding cultivars mean is recommended for maintain conditions because of its frost hardiness.

Mandal and Dana (1993) reported that seed yield exhibited positive and highly significant genotypic association with flag leaf area, number of
grains/ear, length and width of grain and 1000-grain weight. Flag leaf area showed positive correlation with all the traits measured.

Yadav (1993) reported that under saline condition grain yield was positively correlated with tillers per plant and 1000-grain weight. Plant height had positive correlation with tillers per plant and 1000-grain weight.

Theoulakis et al., (1994) estimated the correlation coefficient in F₃ and F₄ between grain yield and harvest index and between grain yield and biomass were high and very high, respectively. From the F₃ to the F₄, the correlation significant for harvest index in all populations, while between harvest index and grain yield were significant in only one population.

Savin et al., (1996) indicated that decreases in grain dry matter were due to reductions in number rather than size of starch granule. It was concluded that high temperature reduced the amount of maltable grain by reducing grain size and increasing the screening percentage and also reduced malt extract by 3-7 percent which represents a large decrease for the malting industry.

El-Hennawy (1997) in interrelationship study showed positive and significant phenotypic and genotypic correlations between grain yield per plant and each of grains/spike, 1000-grain weight and harvest index. Path analysis revealed that grains/spike and 1000-grain weight has the most marked effects of grain yield and could, therefore, be considered for use as selection criteria in barley breeding.

Irfan-ul-Haq (1997) grown twelve (12) husked barley at Faisalabad for correlation and path analysis for grain yield and its components and positive association of grain yield with 1000 grain weight and number of
spikelets per spike. However, grain yield was negatively associated with days to heading.

Singh et al., (1998) evaluated eight elite lines and their 28 F₁ hybrids. The data obtained were used to estimate correlation coefficients. Grain yield/plant was correlated significantly with spikelets/ear, straw strength, tillers/plant and 1000-grain weight. Associations between tillers/plant, spikelets/ear and 1000-grain weight were also positive and significant with grain yield/plant.

Verma et al., (1998) raised eighteen indigenous genotypes of barley cultivars to study correlation and path coefficient among 11 characters. Grain yield showed higher positive and significant association with number of ears/plant, 1000- grain weight. However, positive and significant correlations were also observed for grains/ear, grain weight/ear, 1000-grain weight.

Subhash et al., (1998) conducted a field trial at Jobner, Rajasthan in rabi (winter) 1994-95/barley cv RD 2052 was given 30, 60 or 90 kg N/ha, 0, 15 or 30 kg zinc/ha and 0 or 0.125 percent mixtalol spray yield attributes increased with rate of N application. Application of 60 kg N/ha significantly increased the yield attributed over 30 Kg N but was at par with 90 Kg N. Grain yield had a positive and significant correlation with effective tillers, ear length, number of grain per ear and test weight.

Ram Kishor et al., (2000) reported that grain yield/plant exhibited significant and positive association with plant height, number of tillers per plant, number of grains per ear and 1000-grain weight. The 1000-grain weight was also positively and associated with plant height and number of tillers per plant.
Bhattacharya (2005) studied the nature of direct and indirect effects of the major yield characters in barley by using path analysis. In general genotypic correlation was higher than the phenotypic correlation under all the three irrigated, rainfed and late sown cropping conditions. Grain yield exhibited positive correlation with number of ears per plant and 1000-grain weight, negative association was observed with plant height and ear length.

Singh and Khare (2008) in interrelationship study showed positive and significant phenotypic and genotypic correlations between grain yield per plant and each of grains/spike, 1000-grain weight and harvest index. Path analysis revealed that grains/spike and 100-grain weight has the most marked effects of grain yield and could, therefore, be considered for use as selection criteria in barley breeding.

**PATH COEFFICIENT ANALYSIS**

Singh (1987) reported that days to 75 percent heading had maximum direct effect on yield at the genotypic level and number of ears/plant at the phenotypic level in 11 varieties under irrigated conditions. In rainfed conditions ear length, number of ear/plant, days to 75 percent maturity, number of spikelet/spike exerted a direct effect on yield at the genotypic level while number of ear/plant and number of grains/spike had the greatest effect at the phenotypic level. Under late sowing conditions, the grain yield was directly influenced by the number of grains/spike, plant height, days to 75 percent maturity and 1000-grain weight at the genotypic level and all the characters except number of spikelets/spike at the phenotypic level.

Singh and Singh (1990) studied yield and grain traits of barley (*Hordeum vulgare*) in the parental, F₁ and F₂ generations of an 11-parent
diademe crossing grown during rabi 1986-87 in Varanasi, India. Path
coefficient analysis indicated high positive direct effects on grain yield for
number of internodes and ears per plant under both conditions. Highly
positive indirect effects of grain yield were given by number of internodes
and ears per plant under both conditions and by stem length under
rainfed conditions only.

Garcia et al., (1991) reported that grain yield of barley is influenced
by several yield components and also by the duration of the vegetative and
grain filling periods. Path coefficient analysis based on an autogenetic
approach were conducted to study the relationship among grain yield, yield
components and duration of the vegetative and grain filling periods in 9
genotypes (including seven near isogenic lines) of spring barley varying in
heading dates and several morphological traits grown in two environments
in the province of Granada in southern Spain. Grain yield variation between
environments and from year to year depended mainly on two yield
components: number of spikes/m² and number of grains/spike. Duration of
the vegetative period had a positive influence on grains/spike and a
negative influence on length of the grain filling period.

Ganesheva et al. (1992) studied of height and 8 yield traits in F1
progeny from the crosses 234 x Alfa and Ruen x Alfa; grain per plant and
1000 grain weight had the greatest direct effect on numbers grain weight-
per plant irrespective of whether the phenotypic or genotypic correlations
formed the basis of the path coefficient. These two traits are recommended
as reliable criteria for use in selection for yield.

Mandal and Dana (1993) reported that path coefficient analysis
indicated that number of grains/ear directly influenced of grain yield
followed by 1000-grain weight and width of grain.
Yadav (1993) conducted an experiment during the winter season of 1988-1989, 1989-1990 to study genetic parameters in 25 elite varieties of barley under saline and non-saline conditions. Path coefficient analysis showed the positive and significant correlation of tillers per plant with grain yield was due to its high positive direct effect as well as positive indirect effect via plant height. The high negative effect of spike length was mainly due to direct effect of this component and indirect effect via tillers per plant.

Kudla-MM (1995) obtained information from a study of F2 hybrids from reciprocal crosses. 1000 grain weight had the greatest effect on yield in parents, while ear number per plant had the greatest effect on yield in the hybrids.

Maled-iBG and Hanchinal (1997) recorded the data on 10 Yield components in 26 genotypes of barley grown during rabi 1992 was subjected to path analysis. The spikes per m$^2$ excited the maximum effect on grain yield.

Naik et al., (1998) evaluated twelve genotypes of 6-rowed barley at Dharwad in rabi season and yield was positively correlated with productive tillers/m$^2$. Path coefficient analysis indicated that direct selection for productive tillers/m$^2$, grains/spike and against plant height can improve yield.

Verma et al., (1998) raised eighteen (18) indigenous genotypes of barley to study correlation and path coefficient among 11 characters. The path coefficient analysis revealed that ears per plant, grains per ear and 1000 grains weight were direct contributors to grain yield whereas length of main ear, weight of grains per ear were indirect contributors via three characters.
Fathi and Rezaeimoghddam (2000) observed significant differences between genotypes for grain yield above ground biomass and number of tillers. Among yield components, spike number/m² and number of grains per spike had the largest direct effect on grain yield (0.236). However, its negative indirect effect reduced the correlation coefficient of spike number/m² with grain yield (-0.164). Number of seeds/spike had the highest effect through spike number/m² (0.418) and 1000-grain weight decreased grain yield (-0.055). The number of grains per spikelet had less indirect effect on grain yield through weight in spike and spike number/m² and also had no effect through spike length on grain yield. However, with respect to residual effects (0.529) half of the number/m² and grain number in spike had the largest direct effects on grain yield and that these characters could be used in selection of high yielding barley cultivars.

Pilania (2005) studied path coefficient analysis in barley indicated high positive direct effects on grain yield for number of internodes and ears per plant under both conditions. Highly positive indirect effects of grain yield were given by number of internodes and ears per plant under both conditions and by stem length.

Singh and Khare (2008) showed positive and significant phenotypic and genotypic correlations between grain yield per plant and each of grains per spike, 1000-grain weight and harvest index. Path analysis revealed that grains/spike and 100-grain weight has the most marked effects of grain yield and could, therefore, be considered for use as selection criteria in barley breeding.
STABILITY AND ITS CONCEPT

Genetic diversity plays an important role in preserving the stability of the ecosystems in the biosphere. The term phenotypic stability, yield stability, adaptability and adaptation are quite often used in different senses.

Lewis (1954) defined phenotypic stability as the ability of an individual or population to produce as certain narrow range of phenotypes in different environments.

Allard and Bradshaw (1964) stated that stability does not imply general constancy of phenotype in varying environments. In fact its may, depend on holding some aspects of morphology and physiology in steady state. Thus, the required varieties will show low genotype environment for agriculturally important characters, particularly yield. A variety, which can adjust its genotype or phenotypic state in response to transient fluctuations in environment in such a way that it gives high and stable economic return, can be termed ‘well buffered.

Broadshaw (1965) found that the expression of an individual genotype can be modified by the environment. The amount by which it can be modified, can be termed as ‘plasticity’ and there can be considerable interrelationship among plasticities of different characters.

Lin et al., (1986) amplified that concept of stability is defined in many ways depending on how the scientist wishes to look at the problem. In fact, depending on goal and on the characters under consideration. Two different concepts of stability exists i.e. static and dynamic concept of stability. In case of static concept, a stable genotype possesses an unchanged performance regardless of any variation of the environmental
conditions. This stable genotype shows no deviation from the expected character level that means its variance among environments is zero.

The dynamic concept permits a predictable response to environments and a stable genotype has no deviation from this response to environments meaning thereby that for each environments the performance of a stable genotype corresponds completely to the estimated level, termed the dynamic concept as the agronomic concept of stability or static concept as biological concept of stability. Static concept of stability is useful for traits whose levels have to be maintained at all cost. However, this stability is associated with a relatively poor yield level.

STABILITY PARAMETERS

The inconsistency in the performance of genotypes over a range of environments has been an ever-varying the breeders since long back. Various stability parameters/statistics have been developed to measure the phenotypic stability. The presently used line (g) stability parameters have been reviewed by Plaisted and Peterson (1959), Wricke (1962), Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968); and Lin et al. (1986).

The parametric approach to stability has the advantage of computational simplicity. For the use of proper statistics, the concept of stability and kind of environments, included in the experiment are to be clearly understood. In general, the following statistics are useful if the scientist is concerned about (i) stability over an entire range of environments, then group A (SLi and Cvi) is useful, (ii) Comparing relative stability among the group of cultivars and if regression model fits the data, group C (Finlay and Wilkinson. Perkins and Jinks) is the best. (iii) When the
data do not fit or if the residual MS from the regression are heterogeneous, group B (Wi or C_{ij}^2) is the best and (iv) besides above described season Group 0 (Eberhart and Russell. Perkins and Jinks) is the best.

**VARIANCE G x E INTERACTION**

Plaisted and Peterson (1959) described a procedure to characterize the stability of the performance of several varieties tested at a number of locations within one year. A combined analysis of variance overall locations was computed for every pair of genotypes to estimate the interaction variance of variety x location for each pair of variety \([g(g-1)/2 \text{ pairs}].\) The mean of variance of V x L interaction obtained for each variety/genotypes was used for comparison. The variety with smallest mean value of interaction variance was considered as the most stable variety.

**Ecovalence (Ecological valence)**

Ecovalence (Wi) is the contribution of each genotype to the G x E interaction. Wriclke (1962) proposed ecovalence (Wi) as a stability measure using the G x E interaction effects for each genotype. Squared and summed across all environments. The lower ecovalence of a variety, the smaller are its fluctuations from the experimental mean under different environment and thus a smaller contribution to the G x E interaction. Accordingly, a variety with the least ecovalence (Wi=0) is considered as more stable.

Yates and Cochran (1938) proposed regression analysis to interpret the degree of association between varietal differences and general fertility by calculating the response of yield of separate varieties on the mean yield of all the varieties.
Finlay and Wilkinson (1963) used the simple linear regression to describe various type of variety adaptability to a range of environments, which can also be used as a quantitative measure of phenotypic stability. The observed mean values of each variety are regressed on environmental indexes defined as the difference between the marginal means of environments and the over all mean. The regression coefficient (bi) for each genotype is taken as its stability parameter. Absolute phenotypic stability is expressed by bi=0. This method seems to be quite useful as the regression coefficient represents a greater part of yield variation caused by the environmental fluctuation.

Perkins and Jinks (1968) proposed a biometrical model unlike purely statistical models (Finlay and Wilkinson model and Eberhart and Russell model) which specifies the contribution of genetic, environmental and G x E interaction and extended the analysis to cover many inbred lines and crosses among them. Followed by regression analysis similar to that of Finlay and Wilkinson model except that the observed values are adjusted for location effects before the regression analysis. The G x E effects on environments indices were regressed so that G x E variance to partitioned into a component due to pooled deviation from regression. If either or both have the two components are significantly greater than the experimental error G x E interaction is present if the heterogeneity component alone is significant. All the G x E interaction for an individual genotype can be predicted from the linear regression on environmental values if the remainder component alone is significant there is no simple or linear relationship between G x E interaction and environmental values and hence on predictions can be made by this approach.
Eberhart and Russell (1966) proposed a more elaborate method based on regression technique for measuring the stability of single and three way cross of maize. They calculated an environmental index (l) for each environment as the mean of all varieties at one environment minus the grand mean of all environment and the regression of observed mean values of genotypes are estimated on environmental indices. Further, they introduced deviation parameter ($S^2d_i$) as the residual mean square (MS) of deviation from the regression. The regression ($b_i$) of the variety mean on environmental index and deviation parameter are used as the measures of stability for each genotype. According to their definition, a stable variety is the one having $b=1$ and $S^2d_i=0$. However, a desirable variety is the one which has a high mean ($X_i$), unit regression ($b_i=1$) and deviation from regression as small as possible ($S^2d_i=0$).

Breese (1996) and Paroda and Hayes (1971) advocated the use of regression coefficient as a measure of sensitivity in different crops.

Hadjichristodoulou (1974) found stability of 1000-grain weight and its effect on correlation with 8 other traits were studied in 50 varieties (18 two-rowed and 32 six-rowed barley) at 10 sites with two sowing dates, 30 and 120 kg/ha at each site. Additional material was used to study genotypic correlation among traits. Significance differences in stability of 1000-grain weight were found among 2-rowed varieties were more stable than 6-rowed varieties. The 1000-grain weight was among most stable and grain yield the most variable of trait.

Verma and Ram (1990) found that Huller BHS-25 and Hull less HBS-23 and BHH proved stable for grain yield. Huller BHO-113 and HBO-316 were high yielding but unstable and suitable only for better environment. The stability of regression analysis for studying the
phenotypic stability of grain yield was investigated using a collection of 220 Nordic barley lines. Linear regression explained 26-52 per cent of the genotype x environment interactions in different grouping of the material. The regression coefficient (bi) measures and yield response of the i-th genotype to improve environmental conditions, yield had the highest repeatability with correlations between years ranging from 0.57 to 0.85.

Noaman et al., (1992) conducted field trials in 1988-90 in the northwestern region and north Sinai, 27 lines and cultivars of barley were grown at five environments varying in soil type, soil fertility, precipitation and temperature. Five barley genotypes exhibited both high yield and high stability. Rank correlation showed that environment has influenced some genotypes, while some other genotypes were relatively consistent in ranking at different environments.

Nissila et al., (1992) used four parameters in analysis of yield stability, bi, S^{2}i, \bar{r} and environmental variance (S^{2}i). 6 genotypes of barley and analyzed in each year 6 trials from different parts of Finland from the years 1987-89 The multi year result were considered as reliable data with which to estimate yield stability. The variation between years was highly significant, there was no interaction between genotypes and years on the basis of this study, the genotype x location interaction seems to be more important factor than genotype x year interaction in barley breeding for finish conditions. However, a series of 3 years may not be sufficient for indicating genotype x year interactions.

May et al., (1993) studied the response of barley grain yield to Canadian prairie environments was studied to evaluate genotype x environments interactions with respect to barely genotype selection. Information from a test site and 11 entries over two 3 year span was used.
Genotype x location x year interaction from analysis of variance were significant for grain yield in both data sets.

Oliveira et al., (1994) evaluated 14 genetically diverse barley genotypes at St. Paul in 1990-92 and at Crookston in 1990 and 1991, and four populations (resulting from crosses of an 6 row Minnesota line, M 66 with each of 4 European 2 row genotypes, Cheir, Remina. Caebcco 8858 and SV 83637). Data were obtained using digital image analysis of starch granules. Significant differences were found among the 14 barley genotypes for six granule traits. Environment had a significant effect on four granule traits, but genotype x environment interaction (G x E) were not significant. Heritabilities were encouraging on a genotype mean basis in the 14-genotype study.

Fekadu-Fufa (1995) evaluated 15 barley genotypes in five environments in North-Western Ethiopia to determine their performance and stability. The combined analysis of variance showed highly significant (P less than 0.01) genotype, environment and genotype x environment effect on grain yield. The regression coefficient for the 15 genotypes ranged from 0.884 to 1.348 and were not significantly different from 1.00. Genotypes PG 3510 (I), PG 3515 (I), and PG 319 (I) with regression coefficient close to 1.00, minimum deviation from regression and which had mean yield above the grand mean were equally stable. In performance across the environment Kulumasa 1/88 and Kulumasa 7/88 in that order appeared more productive were growing conditions are favourable.

Nurminieml et al., (1996) studied the suitability of regression analysis for phenotypic stability of grain yield using a collection of 220 Nordic barley lines. Linear regression explained 26-52 percent of genotype x environment (G x E) interactions in different grouping of the material yield.
had the highest repeatability, with correlations between years ranging from 0.57 to 0.85. Genotype react differently to the yearly climatic variations. Six rowed barleys had higher responsiveness. But lower mean yield, than two rowed barely.

Das et al., (1996) reported the significant differences among varieties for all the characters under study, revealing the presence of sufficient variability in the genetic materials. Mean square due to environment genotype x environment interaction showed differential response of genotypes with respect to environments. Both linear and nonlinear components of G x E interactions were significant for productive tillers/m² and grains per panicle.

Kara, (1997) evaluated 12 bread wheat genotypes over five environments to evaluate different stability parameters and rank correlations among them. From the information on mean yield and comparative stability parameters, Kate-A1 was judged as the most stable genotype. The mean yield was significantly correlated with coefficient of determination (r²i). The linear regression (b) statistic showed significant positive correlation with genotypic variance (S²ji) and coefficient variability (Cvi). The covalence stability index (W²i) and stability variance were perfectly correlated (r=1.00).

Przulj et al., (1997) analyzed in 10 spring malting barley genotypes, grown at Novi Sad in 1986-88. The importance of genotype x year interaction for malt fine extract and grain protein contents was determined by means of the regression coefficient and deviation from regression as parameters of stability. The malt fine extract content depend mainly on the year. A significant positive correlation was found between yield and the coefficient of regression for malt fine extract content.
Salem et al., (1998) indicated that the genotype x environment interaction components accounted for the most part of the total variation for grain yield and its components i.e. spikes/m², grain/spike and 1000-grain weight. Regression coefficient (bi) values varied among the genotypes.

Thakur et al., (1999) conducted trial on 75 cultivars of barley of wide origin under rain fed conditions over 3 years for stability analysis. DL-78 and DL-226 were stable for high yields and are suitable for commercial cultivation. Ratan having a high production potential may be suitable for specific favourable environments.

Farshadfar (1999) reported that the relative contribution of seeds/spike in the genotype-environment interactions was higher than those of spikes/plant and seed weight. It was also observed that the sensitivity of seeds/spike to the environmental fluctuations was less than that of the other two components and hence plays a more important role in the phenotypic stability of wheat.

Upreti (1999) reported the presence of G x E interaction for all the characters except tillers per meter. The linear component of G x E interactions was significant for days to head, days to maturity, spike length, grains per spike and 1000-grain weight. Non-linear component was significant for most of the characters except days to maturity, spike length and spikelets per spike.

Mishra et al., (2000) reported that eight promising wheat genotypes (GW-190, 01-803-3, Raj-1555, WH-142, DL-DL-788-2 and WH-533) were sown in Madhya Pradesh, India during 1996-97 and 1997-98 on 3 different dates (normal, 22 November, late, 2 December, and very late, 12 December) Results showed that DL-788-2 and GW-190 had higher
adaptability and stability, and may be recommended for normal and late sowing conditions. The cultivar WH-147 was responsive to rich environments and may be recommended for cultivation based on normal sowing dates. DL-803-3 and Raj-1555 showed stability and sustainability under poor environmental conditions and may be recommended for cultivation under late sowing conditions.

Sial et al., (2000) reported that the stability for Yield performance and genotype x environment (G x E) interaction was studied in 12 wheat (Triticum aestivum) genotypes grown at 13 contrasting sites. The combined analysis of variance over all environments revealed highly significant (P < 0.01) difference for genotypes, environments and G x E interaction. An adaptation analysis was applied to estimate the (bi) and deviation from regression coefficients (S^2d) for each genotype.

Costa et al., (2001) obtained information from barley cultivars across 17 environments (location x years) in Maryland, USA from 1994 to 1997 and to examine the effect of locations and years of testing on grain yield performance in this region. Significant differences were observed among barley cultivars and experimental lines for grain yield, plant height and heading data. Grain yield was positively correlated with plant height and negatively with heading date. Genotype x environment interactions measured through regression analysis were significant for grain yield, heading date and plant height. Most barley genotypes tested (90%) had regression slope for grain Yield that did not differ from 1.0.

Pilania and Dhaka (2004) stated that stability does not imply general constancy of phenotype in varying environments. In fact it may depend on holding some aspects of morphology and physiology in steady state. Thus, the required varieties will show low genotype environment for
agriculturally important characters, particularly yield. A variety, which can adjust its genotype or phenotypic state in response to transient fluctuations in environment in such a way that it gives high and stable economic return, can be termed 'well buffered'.

Dhama (2007) stated the significant differences among varieties for all the characters under study revealing the presence of sufficient variability in the genetic materials. Mean square due to environment + genotype x environment interaction showed differential response of genotypes with respect to environments. Both linear and non-linear components of G x E interactions were significant for productive tillers/m² and grains per panicle.

Verma (2008) reported the importance of genotype x location interaction for malt fine extract and grain protein contents was determined by means of the regression coefficient and deviation from regression as parameters of stability. The malt fine extract content depends mainly on the location. A significant positive correlation was found between yield and the coefficient of regression for malt fine extract content.