Pak. J. Bot., 10 (1): 9—15, 1978.

# GENOTYPE-ENVIRONMENT INTERACTION IN BARLEY VARIETIES SUITABLE FOR NORTHERN IRAQ

M. H. KASIM

*Department of Biology, College of Science, University of Mosul, Mosul, Iraq.*

**Abstract**

The joint regression analysis technique was used to investigate the adaptation of seven varieties of barley (Aswad, V-Pallidum 1337, V-Mex. II, 1105/1, V-Well, V-11941, and Arivat) grown under six, natural dry-farming environments of Northern Iraq. Aswad and V-Pallidum 1337 responded well below the average. They were adapted to low yielding environments but were relatively unstable. On the other hand V-11941 and Arivat responded well above the average. The latter varieties were adapted to high yielding environments but were relatively the most stable varieties in Northern Iraq.

## Introduction

Genotype-environment (GE) interactions have been of concern to geneticists and plant breeders for many years. Various procedures have been used to characterize adapted varieties. Performance tests over a series of environmental conditions when analyzed in the conventional manner give information on GE interactions (Rasmusson & Lambert, 1961). but these tests do not measure the stability of individual varieties. Comstock & Moll (1963) showed statistically the effect of large GE interactions in reducing progress of selection. Eberhart & Russell (1966) indicated several methods of reducing the GE interaction effects such as environmental stratification, use of multiline variety, or use of heterozygous and heterogeneous population; however, they still emphasized the importance of selecting stable genotypes that interact less with the environments in which they are grown.

The joint regression analysis technique has been used widely for measurement of stability of different plant genotypes. It was reported and used by a series of authors, for example, Yates & Cochran (1938), Finlay & Wilkinson (1963), Eberhart & Russell (1966), Breesse (1969), and Johnson & Whittington (1977). Bradshaw (1973) pointed out the disadvantage of this type of analysis and emphasized testing the reaction of genotypes to individual environmental factors. However, the joint regression analysis technique has been further developed recently by Perkins & Jinks (1968 a, b, 1973), Westerman & Lawrence (1970), Westerman (1971 a,b,c), and Freeman & Dowker (1973). The parameters of this analysis were included in biometrical genetic models of GE interaction (Mather & Jinks 1974). The technique, therefore, has been used very successfully in prediction of genotypic performance for a range of species and environments.

The most important cereal crops of Iraq are wheat and barley which are grown mostly as rainfed crops in Northern Iraq including Northern Jazerah plains. The yield of these crops plays a very vital role in the entire economy of the country.

**TABLE 1. Analysis of variance for grain yield (kg/ha) of seven barley varieties grown in six, natural environments in Northern Iraq in seasons 1973-74 and 1974-75.**

| Variance source | DF | | Mean squares |
|---|---|---|---|
| Environments | 5 | | 53926189.9** |
| Locations | | 2 | 83808036.2** |
| Years | | 1 | 4997325.1** |
| Loca. X years | | 2 | 48508776.0** |
| Genotypes | 6 | | 978101.9** |
| Geno. X envi. | 30 | | 441753.7** |
| Geno. X loca. | | 12 | 896456.7** |
| Geno. X years | | 6 | 122213.6NS |
| Geno. X loca. X years | | 12 | 146820.9NS |
| Regressions | 6 | | 1840582.5** |
| Deviations | 24 | | 94026.5NS |
| Rep. within loca. & years | 18 | | 228079.9NS |
| Residual | 108 | | 172984.9 |

*Significant at 0.01 level; NS-Not significant.

Since the main purpose of this analysis is to search for a stable variety, the GE interaction mean square was partitioned into linear regressions and deviation from linear regressions mean squares; so that stability of individual varieties could be assessed. Table 1 shows that linear regressions mean square is highly significant and it is about 20 times larger than that for deviation from regressions, which indicates that the genotype-environmental interactions of any variety are a linear function of the environmental values and there are highly significant differences among the slopes of the regression lines. It is thus clear that the varietal yield responses so measured were linear and differences between the varieties could be largely explained by difference between the slopes of their linear regressions. However, the deviation from linear regressions mean square is small and not significant, which shows that deviations from linearity due to the unpredictable irregularities in the response to environments are small and not important. As illustration, individual points were plotted for V-Pallidum 1337 and Arivat in Fig. 1, but were not plotted for all varieties in Fig 2.

**TABLE 2. Grain yield (kg/ha) and regression coeffcient (b) of seven barley varieties grown in six, natural environments of Northern Iraq in seasons 1973-74and1974-75.**

| Variety | Mean | Range | b ± SE |
|---|---|---|---|
| Aswad | 1862.7 | 435.4—3550.0 | 0.845 ± 0.075 |
| V-*Pallidum* 1337 | 2033.8 | 290.7—3472.9 | 0.822 ± 0.105 |
| V-Mex. II | 2193.3 | 234.4—4218.8 | 1.038 ± 0.010** |
| 1105/1 | 2281.3 | 221.9—3935.4 | 1.015 ± 0.025 |
| V-Well | 2355.0 | 301.1—4666.7 | 1.051 ± 0.124 |
| V-11941 | 2382.5 | 244.8—4310.4 | 1.084 ± 0.016** |
| Arivat | 2402.3 | 249.0—4693.8 | 1.145 ± 0.015** |

LSD at (.05) = 166.4

Population mean = 2215.8±32.1

**Significantly different from unity at the 0.01 level.

Aswad, V-Pallidum 1337, 1105/1, and V-Well have regression coefficients with relatively large deviations (.025 to .124). These varieties are, therefore, unstable in their response to environments. V-Mex. II, V-11941, and Arivat, however, show relatively small deviations (.010 to .016) and are thus stable in their response to environments according to Eberhart& Russell (1966), Perking & Jink (1968 b), and Breesse (1969).

Knight (1970) reviewed the regression analysis and demonstrated the response of different genotypes to specific levels of environmental factors to be curvilinear. In this paper, however, the response of the seven different genotypes to the

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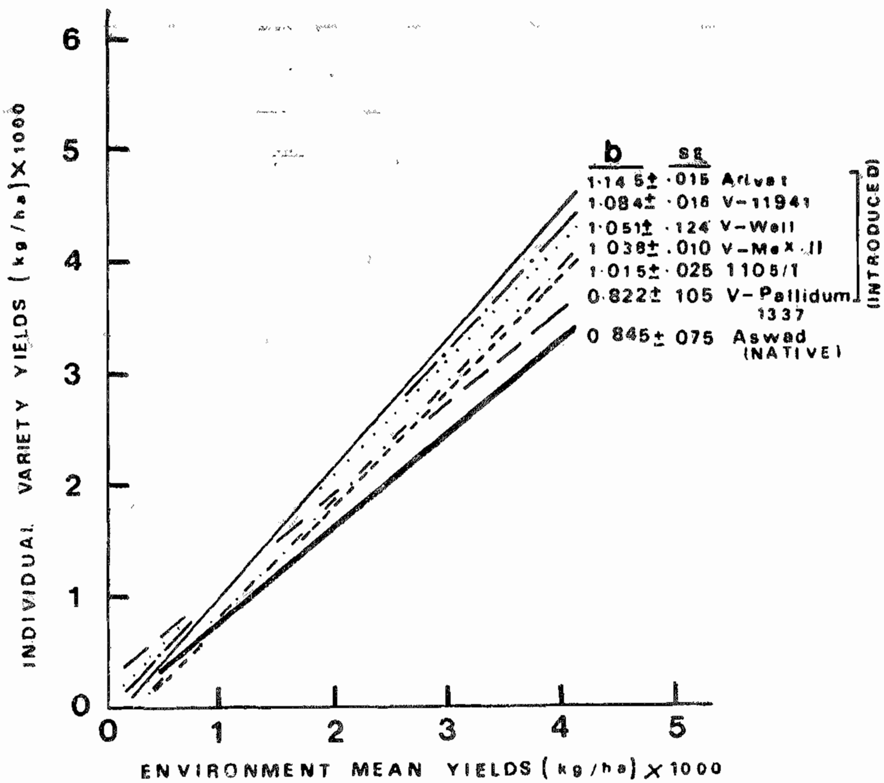


Fig. 2. Regressions of seven individual variety yields on their environment yields.

six natural environments (without trans form ation of data) is very clearly linear (Fig. 1 and Fig. 2) and supported by the highly significant linear regression mean square (Table 1). Therefore, the joint regression analysis technique is a valuable method in predicting genotypic adaptation of different genotypes in northern Iraq, especially when the different genotypes are assessed over a random sample of natural environments.

## Acknowledgments

This investigation was conducted in the Department of Botany, University of Liverpool, England, while the author was on a sabbatical leave from the University of Mosul, Iraq. The author is grateful to Professor A.D. Bradshaw, Dr. K. Hardwick, and Dr. T. Mc Neilly for encouragement during the course of the investigtion and for critical reading of the manuscript.

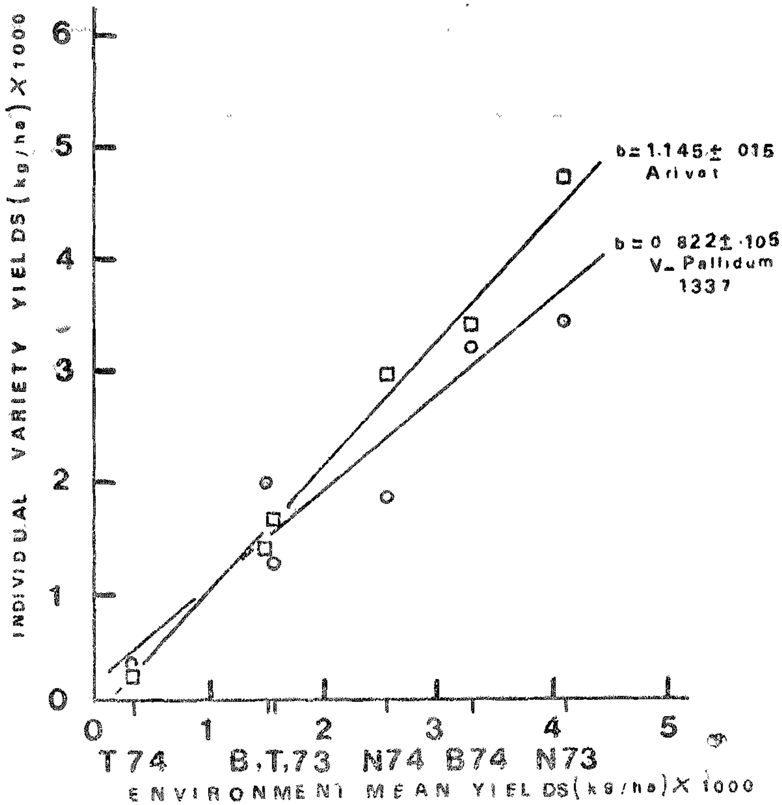


Fig. 1. Regressions of two individual variety yields on their environment yields. T, B, N, 72 and 74 represent Talla'afar, Bakrahcho, Nineveh locations during 1973-74, and 1974-75 growing seasons, respectively.

The performance of each variety is summarized by its mean, range, and regression coefficient in Table 2 and Fig. 2. The very low standard errors for regression coefficients indicate that individual points are in good agreement with the fitted linear regressions. The rather narrow range of varietal regression coefficients (0.822-1.145) were expected because these varieties had been selected after preliminary yeild trials of a large number of introduced varieties in the dry-farming conditions of Northern Iraq. Awwad and V-Pallidum 1337 have (b) values not significantly lower than unity and those of the other varieties, which shows that these two varieties responded well below the average and they were adapted to low yielding environments. V-Mex. II with a (b)=1.038 highly significant, greater than unity, is specially adapted to high yielding environments. 1105/1 and V-Well show regression coefficients not significantly higher than unity, which indicates that these two varieties responded well to average environments. V-11941 and Arivat have regression coefficients significantly greater than unity and responded well above the average. They were adapted to high yielding environments. It will be noted in Table 2 and Fig. 2 that

Seasonal fluctuation in yield of these crops is highly undesirable in Iraq. Thus it is necessary to evaluate promising introduced varities over a wide range of environental conditions of Northern Iraq and to release adapted varieties that perform well over a wide range of environments. The objective of the present paper is to investigate the value of regression analysis technique for grain yield of seven varieties of barley grown under six, natural, dry-farming environments of Northern Iraq.

## Materials and Methods

The material used in this study comprised seven varieties of barley grown at three locations which were Ninevah, Talla' afar, and Bakrahcho (representing dry-farming fields in Northern Iraq) during the growing seasons of 1973-74 and 1974-75. The sowing dates of the growing season 1973-74 were on 12th, 12th, and 15th November at Talla'afar, Ninevah, and Bakrahcho, respectively. But the sowing dates of the growing season 1974-75 were 27th October, 13th November, and 27th November at Bakrahcho, Talla' afar, and Ninevah, respectively. The author thanks the Cereal and Legume Department, Ministry of Agriculture, Iraq, for allowing him to extract the original yield data from the Departmental files. The seven varieties used were: Aswad (a native variety), V-Pallidum 1337, V-Mex. II, 1105/1, V-Well, V-11941, and Arivat (all introduced varieties). The experimental design used at each location was a randomized complete-block with four replications. Every variety was planted in a ten row plot. The row length was five metres and in each 15 g of grain were planted. Rows were 30 cm apart. The ranges of number of days from date of sowing to maturity for the seven varieties were as the following:

| Growing season | Talla' afar | Ninevah | Bakrahcho |
|---|---|---|---|
| 1973-74 | 188-194 | 189-194 | Not available |
| 1974-75 | 181-189 | 162-172 | 210-222 |

Eight central rows from each plot were harvested for grain yield evaluation. In order to compare the performance of the varieties, yield data for each one of them was subjected to a linear regression analysis of its yield on the yield of all varieties for each location in each season. The data are presented in kg/ha.

## Results and Discussion

The analysis of variance for grain yield shows highly significant differences among the seven genotypes grown in the six, natural environments (Table 1). The highly significant genetic differences among the varoities show that they must carry genes with different additive effects, which can be related to their different origins. Differences in performance of the varieties in the three locations are demonstraetd by highly significant genotypes X locations interactions, which could result from inconsistency of additive effects, inconsistency of non-allelic interaction effects, or from both cases under the different locations, during the two years. Since the response to environment is under genetic control (Bradshaw 1973: Khan & Bradshaw, 1976), it is possible to recommend particular varieites for particular locations in Northern Iraq (Allard & Bradshaw 1964). However, genotypes X years mean square is not significant indicating that the seven varietis did not react differently to seasonal effects in the two years. Partition of environmental mean square into locations and years mean squares shows that locations mean square is about 17 times larger than years mean square.