

Genetic Variation, Heritability, Phenotypic and Genotypic Correlation Studies for Yield and Yield Components in Promising Barley Genotypes

Jalal A. Al-Tabbal (Corresponding author)

Department of Applied Science, Al-Huson University College

Al-Balqa' Applied University, Al-Huson, Jordan

Tel: 962-79-766-0137 E-mail: Jaltabbal@bau.edu.jo

Ahmad H. Al-Fraihat

Department of Applied Science, Ajloun University College

Al-Balqa' Applied University, Ajloun, Jordan

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Abstract

Eighty six promising new barley genotypes and three checks including one indigenous cultivar (*Hordeum vulgare* L. var Rum) were grown in two successive seasons of 2005 and 2006 to assess the presence of variability for desired traits and amount of variation for different parameters. Genetic parameters, correlations, and partial regressions were estimated for all the traits. Analysis of variance revealed significant differences among entries for all the characters. The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were high for grain yield per plant, biological yield and number of kernels per main spike. Broad sense heritability estimates for various traits ranged from 68 to 99.7%. Grain yield per plant showed high significant positive genetic and phenotypic correlation with only number of kernels per main spike. Multiple correlations of characters (0.36), *via.* fertile tiller number and number of kernels per main spike which were significant with grain yield were far from the multiple correlation of all characters (0.96). The total variability calculated through multiple correlation in the population for yield improvement accounted by fertile tiller number and number of kernels per main spike was 36 % compared to 96 % accounted by all other characters. It was concluded that more fertile tiller number and number of kernels per main spike are major yield contributing factors in selecting high yielding barley cultivars.

Keywords: Phenotypic, Genotypic, Coefficient, Variation, Genetic advance, Heritability, Barley

1. Introduction

Barley is a fourth most important cereal crop after wheat, rice and maize, cultivated successfully in a wide range of climate. This crop has potentials for growing under drought and saline conditions. Barley grain is used as feed, food, while barley straw provides an important source of roughage. In Jordan, barley is the predominant crop in areas of below 300 mm of annual rainfall, which are characterized by high interseasonal and intraseasonal variation in terms of amount and distribution of rainfall. In these areas barley is mainly grown as animal feed and both the grain and the straw are utilized (Al-Jamali et al. 2002; Tawaha and Turk 2002; Turk et al. 2003). The world production of barley decreased by 3.5% during the period 1995-1998 to 2005-2008, while in Jordan, barley production decreased by 57% (FAO, 2009). The low productivity of barley in Jordan is due to wide seasonal variability, low amount of rainfall, poor soil moisture conservation, poor stand resulting from lack of weed control, and low yield potential genotypes (Tawaha et al. 2001, 2002, 2003; Turk and Tawaha 2003; Al-Jamali et al. 2002; Tawaha and Turk 2002; Turk et al. 2003).

Different methods could be used to increase cereal production, such as increasing area of production, effective cultural practices, and using improved cultivars (Cassman 1999). In Jordan, as land is limited and most of the production area is under semi-arid conditions, developing high-yielding cultivars adapted to local conditions could

be employed, understanding the magnitude of existing variability, proper characterization of the most important physiological traits and their interrelationships with yield and yield components would be extremely helpful in the synthesis of most efficient and highly productive genotypes (Joshi et al. 1982). So, cereal improvement depends on the continuous supply of new germplasm as donors of various genes of agronomic importance. The development of high yielding-cultivars is the main objective of any breeding programs in the world (Ehdaie and Waines, 1989). One of the main objectives of any breeding program is to produce high-yielding and better-quality lines for release as cultivars to farmers. The prerequisite to achieve this goal is to find sufficient amount of variability, in which desired lines are to be selected for further manipulation to achieve the target. Introduction of new populations can be made from one region to the other easily and may be used for further manipulation to develop new breeding lines (Ifftikhar et al., 2009). Identification of better genotypes with desirable traits and their subsequent use in breeding program and establishment of suitable selection criteria can be helpful for successful varietals improvement program. Analysis of variability among the traits and the association of a particular character in relation to other traits contributing to yield of a crop would be of great importance in planning a successful breeding program (Mary and Gopalan 2006). Development of high-yielding cultivars requires a thorough knowledge of the existing genetic variation for yield and its components. The observed variability is a combined estimate of genetic and environmental causes, of which only the former one is heritable. However, estimates of heritability alone do not provide an idea about the expected gain in the next generation, but have to be considered in conjunction with estimates of genetic advance, the change in mean value among successive generations (Shukla et al., 2006). A survey of genetic variability with the help of suitable parameters such as genetic coefficient of variation, heritability estimates and genetic advance are absolutely necessary to start an efficient breeding program (Atta et al., 2008). Assessment of the extent of genetic variability within barley, is fundamental for barley breeding programs and the conservation of genetic resources, and is particularly useful as a general guide in the choice of parents for breeding hybrids. The objectives of the present study were to assess and evaluate genetic variability of barley germplasm based on agro-morphological traits.

2. Materials and Methods

2.1 Plant Materials

Eighty six promising new barley genotypes from the International Center for Agricultural Research in the Dry Areas (ICARDA) were used. *Harmal* (the improved 2-rowed check variety), *Matnan-01* (the improved 6-rowed check variety), and Rum (the improved 6-rowed local check variety) were the checks. Entry name and pedigree are presented in Table 1.

2.2 Field Experimental Setup

Genotypes were sown in the first week of December 2005 and the second week of December 2006 in Al-huson Field Campus in a randomized complete block design with three replications. The experimental plots consisted of 6 rows of 2.5 m length with 30 cm spaces and they were sown by hand. The plant density of 300 plants per m² and recommended dose of fertilizer (100:70:50, NPK) kg per ha were applied. Weeds were removed by hand prior to flowering stage. Standard cultural practices were followed for raising the crop.

2.3 Weather Conditions

The precipitation and average temperature for the 2005/2006 and 2006/2007 cropping seasons in Al-huson Field Campus are presented in Table 2. Total precipitation in 2005/ 2006 was 261.8 mm, while it was 276.8 mm in 2006/2007.

2.4 Characters Studied

The characters measured included biological yield per plant (g) (BY), grain yield per plant (g) (GY), plant height (cm) (PH) (measured from the base of the plant to the tip of the plant at the time of physiological maturity), tillers per plant (TN) (recorded by counting the number of tillers per plant selected at random), number of fertile tillers (FTN), number of kernels per main spike (KN), thousand kernel weight of main spike (g) (TKW), number of days to heading (HD) (counted from the date of sowing to the date on which approximately 50% tillers produced spikes.), number of days to maturity (MD) (calculated when the plants were physiologically mature (the stage when color of plant changes from green to golden yellow and its tillers can break easily with hands)), and grain filling period (GFP). From these measurements, estimates of harvest index using Eq. 1 were also computed and analyzed.

$$HI = GY/BY \quad (1)$$

2.5 Genetic Parameters Estimates

Heritability in broad sense (H^2 or h^2) was estimated according to Falconer (1989) using eq. 2:

$$h^2 = \frac{\sigma^2_g}{\sigma^2_{ph}} \quad (2)$$

h^2 : Heritability; σ^2_g : genotypic variance and σ^2_{ph} : phenotypic variance. Genotypic (σ^2_g) and Phenotypic variances (σ^2_{ph}) were obtained from the analysis of variance table according to Comstock and Robinson (1952) using eq. 3 and eq. 4:

$$\sigma^2_g = \frac{MS_1 - MS_2}{r \times s} \quad (3)$$

$$\sigma^2_{ph} = \frac{MS_1}{r \times s} \quad (4)$$

(Where r: replication, s: season MS1: Mean square for cultivar, MS2: Mean square for cultivar \times season).

The mean values were used for genetic analyses to determine Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV), according to Singh and Chaudhury (1985) using eq. 5 and eq. 6:

$$GCV (\%) = \frac{\sqrt{\sigma^2_g}}{X} * 100 \quad (5)$$

$$PCV (\%) = \frac{\sqrt{\sigma^2_{ph}}}{X} * 100 \quad (6)$$

Where:

σ^2_g = genotypic variance.

σ^2_{ph} = phenotypic variance.

X = sample mean.

Genetic advance (GA) was calculated with the method suggested by Allard (1960); Singh and Chaudhury (1985) using eq. 7:

$$GA = k . \sigma_{ph} . h^2 \quad (7)$$

Where

GA: genetic advance.

K: constant = 2.06 at 5% selection intensity.

σ_{ph} : square root of phenotypic variance .

h^2 : Heritability.

$$GA \text{ as } \% \text{ of mean (GAM)} = (GA/\text{mean value}) * 100 \quad (8)$$

Phenotypic and genotypic correlations were estimated using the standard procedure suggested by Miller et al. (1958) and Kashiani and Saleh (2010) from the corresponding variance and covariance components using eq. 9 and eq. 10:

Phenotypic correlation coefficient

$$r_{pxy} = \frac{\sigma_{pxy}}{\sqrt{\sigma^2_{px} * \sigma^2_{py}}} \quad (9)$$

Genotypic correlation coefficient

$$r_{gxy} = \frac{\sigma_{gxy}}{\sqrt{\sigma^2_{gx} * \sigma^2_{gy}}} \quad (10)$$

Where, r_{pxy} = phenotypic correlation coefficient between characters X and Y and r_{gxy} = Genotypic correlation coefficients between characters X and Y.

2.6 Statistical Analysis

Analysis of variance, using randomized complete block design, was computed for all the characters evaluated using the computer software system of SAS (SAS Institute, 2002).

3. Results

3.1 Phenotypic Variation

The results from analyses of variance over two years for the investigated characteristics are presented in Table 3. Grain yield and some grain quality characteristics of the eighty six promising new barley genotypes and the three check cultivars which were introduced from ICARDA were assessed in a two year study and a high significant variability among the promising barley genotypes were determined with respect to the studied parameters (Table 4). Effects of cultivar (V) and year (Y) were found to be significant for all the parameters, except for the effect of year of grain yield per plant, biological yield per plant, harvest index per plant, and thousand kernel weight. However, the interaction of $Y \times V$ was not significant. The mean values of the characteristics studied are shown in Table 5.

3.2 Promising Barley Genotypes VS Standard Cultivars

Comparisons between the promising barley genotypes and the improved cultivars revealed that, in general, promising barley genotypes were similar to the check cultivars except for kernel number and heading date. Local check cultivar (Rum) has greater number of kernels than the promising barley genotypes. Also, Matnan check was later in heading than other promising barley genotypes. The mean values of other characters compared to the check cultivars are presented in Table 5. There was one promising barley genotype (Entry no. 76) that was superior to the local check Rum for grain yield per plant. The grain yield and other characters of the superior plant and check cultivars are presented in Table 6. Among yield components, this genotype (Entry no. 76) was better than the check in kernel number and fertile tillers number.

3.3 Genetic Variability

In trying to determine the extent to which variation in yield components are responsible for differences in yield among various cultivars, it must be borne in mind that overall variability depends on heritable and non-heritable components. While coefficients of variation measure the magnitude of variability present in a population, estimates of heritability and genetic advances are important preliminary steps in any breeding program as they provide information needed in designing the most effective breeding program and the relative practicability of selection. Genotypic variance, phenotypic variance, genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), broad sense heritability, genetic advance and genetic advance expressed as percentage of mean for 11 characters are presented in Table 7.

3.4 Estimates of Heritability

The results revealed considerable phenotypic and genotypic variances among the genotypes for the traits under consideration. In all traits a large portion of the phenotypic variance was accounted for by the genetic component and the contributions of genetic variance to phenotypic variance were more than 67% (Table 7). The estimates of GCV were high for number of kernels per main spike (35.24), grain yield per plant (26.04), biological yield per plant (22.86), grain filling period (19.40), fertile tillers number (16.28), and plant height (15.91). The remaining traits recorded moderate to low GCV estimates. The PCV values were higher than GCV values for all the traits which reflect the influence of environment on the expression of traits. The results of heritability indicated that moderate heritability values were recorded for number of tillers per plant and fertile tillers number, while high heritability estimates for other yield components (number of kernels per main spike and thousand kernel weight) (Table 8).

3.5 Estimates of Expected Genetic Advance

The expected genetic advance values for 11 characters of the genotypes evaluated is presented in Table 7. These values are also expressed as percentage of the genotypes mean for each character so that comparison could be made among various characters, which had different units of measurement. High heritability along with high genetic advance is an important factor for predicting the resultant effect for selecting the best individuals. Number of kernels per main spike, grain yield per plant, biological yield per plant, plant height, grain filling period, thousand kernel weight and fertile tillers number had high heritability accompanied with high genetic advance, while maturity date, heading date, number of tillers per plant and harvest index had high heritability coupled with low genetic advance.

3.6 Genotypic and Phenotypic Correlations among Characters

The phenotypic and genotypic correlations for morpho-agronomic traits are presented in Table 8. Number of kernels per main spike, which is the main component of grain yield, gave the highest positive significant phenotypic and genotypic association with grain yield per plant implying that improving this character could result in high grain yield. Since yield of grain is the product of number of spikes, number of kernels per spike, and kernel weight, all assume importance in efforts to attain new levels of productivity in barley. Number of productive tillers per plant had a highly significant genotypic correlation with grain yield but had low phenotypic correlation. The significant positive correlation of tillers per plant with yield per plant have been reported by Mondal et al. (1997) and that of number of grains per spike by Raut et al. (1995). Physio-morphological trait, i.e. plant height ranked second after yield components (number of kernels per main spike and number of productive tillers) in their positive associations with grain yield. A positive association between grain yield and grain filling period was obtained. On the contrary, grain yield had strong negative correlation ($P < 0.01$) with days to heading.

3.7 Multiple Correlation and Regression Analysis

In order to determine the effect of morphological traits on grain yield, multiple correlation analyses were carried out (Table 9). The joint association through multiple correlations of all characters studied with yield was highly significant. Multiple correlations of characters (0.36), *via*. fertile tillers number and number of kernels per main spike, which were significant with grain yield were far from the multiple correlation of all characters (0.96).

The significance of partial regression coefficients was also tested (Table 10). Partial regression analysis of grain yield on the basis of all yield components are given in Table 10a. Yield showed a significant partial regression coefficient with fertile tillers number, number of kernels per main spike and heading date. The selection of best regression equation done through backward elimination procedure revealed that fertile tillers number, number of kernels per main spike and heading date were the most effective variables contributing to the grain yield. The partial regression coefficients of fertile tillers number (0.47) and number of kernels per main spike (0.05) were significant (Table 10b). The best regression equation to bring the maximum improvement in the grain yield has been shown in eq. 11 as follow:

$$Y = 0.376 + 0.47 X_1 + 0.05 X_4 \quad (11)$$

Where, x_1 : Fertile tillers number, x_4 : Number of kernels per main spike.

4. Discussion

The significant differences among barley genotypes in the investigation indicate the presence of genetic variability in the material used and provide a good opportunity for yield improvement. Grain yield and other characters exhibited stability across the seasons since the significance of genotype \times environment interaction was not detected and the differences among genotypes were obvious (Table 4). This appears to show that further improvement through selection for all characters studied could be effective. High ratios of the genotypic variance to phenotypic variance for biological yield per plant, grain yield per plant, number of kernels per main spike, thousand kernel weight, plant height, heading date, maturity date and grain filling period indicate the existence of immense inherent variability that remains unaltered by environmental conditions among the genotypes, which in turn is more useful for exploitation in selection and hybridization programs.

Although the genotypic coefficient of variation revealed the extent of genetic variability present in the genotypes for various traits, it does not provide full scope to assess the variation that is heritable. Heritable variation is useful for permanent genetic improvement (Singh, 2000). The most important function of the heritability in the genetic study of quantitative characters is its predictive role to indicate the reliability of the phenotypic value as a guide to breeding value (Dabholkar 1992; Falconer and Mackay 1996). The genotypic coefficient of variation along with heritability estimates provide reliable estimates of the amount of genetic advance to be expected through phenotypic selection (Burton, 1952). High heritability estimates for grain yield, number of kernels per main spike, plant height and thousand kernel weight indicate a high response to selection in these traits (Shadakshari et al., 1995; Shan and Mishra, 1995) and this results were also reported by (Sachan and Singh, 2003; Siddique et al. 2006; Ali et al., 2008; Adewale et al., 2010; Rahim et al., 2010; Riaz-Ud-Din et al., 2010) which support the present findings. Heritability and genetic advance are important selection parameters. The estimate of genetic advance is more useful as a selection tool when considered jointly with heritability estimates (Johnson et al., 1955). The estimates of genetic advance help in understanding the type of gene action involved in the expression of various polygenic characters. High values of genetic advance are indicative of additive gene action whereas low values are indicative of non-additive gene action (Singh and Narayanan, 1993). Thus the heritability estimates will be reliable if accompanied by high genetic advance.

High heritability accompanied with high genetic advance as percent of the mean in case of number of kernels per main spike, grain yield per plant, biological yield per plant, plant height, grain filling period, thousand kernel weight and fertile tillers number indicate that these are simply inherited traits and most likely the heritability is due to additive gene effects and selection may be effective in early generations for these traits. Similar findings have been reported by some authors (Dwivedi et al., 2002; Sharma and Garg, 2002; Ali et al., 2008). However, maturity date, heading date, number of tillers per plant and harvest index had high heritability coupled with low genetic advance indicates non-additive gene effects.

From the above discussion, kernel weight of main spike, grain yield per plant, number of kernels per main spike, biological yield per plant, and plant height were shown to have high to moderate genotypic variance, high to moderate heritability and greater genetic gain. Selection can therefore be based on these characters and their phenotypic expression would be a good indicator of their genotypic potentiality. The remaining traits recorded lower scores in the three genetic parameters considered in this study and therefore offered less scope for selection as they were much more under the influence of the environment. An understanding of inter-character correlation is essential to successful selection of useful genotypes from the whole population but intensive selection for any characteristic might result in losses in others (Lebsock and Amaya, 1969). The magnitude of the genotypic and phenotypic correlations and their utilization in the selection had been stated by a number of researchers (Van Oosteron and Acevedo, 1992; Gashaw, 2007; Ali et al., 2008). Genotypic correlation coefficient offers a measure of the genetic association between characteristics and may provide an important criterion of the selection procedures (Can and Yoshida, 1999). Genotypic correlation coefficient values were greater for most of the characters than their corresponding phenotypic correlation coefficient values, indicating inherent association of the characters. Positive significant associations were obtained between grain yield and plant height because these tall lines generally excelled in their capacity to support kernel growth by stem reserve mobilization (Blum et al., 1989). Therefore, selection for tall plants tends to increase grain yield per plant. The present study suggests that a positive association between grain yield and grain filling period and a negative association with days to heading were obtained. Previous studies have confirmed this result (Gebeyehou et al., 1982; Amin et al., 1992; Van Oosteron and Acevedo, 1992; Gashaw, 2007), which means that early heading genotypes with adequate grain filling period escape terminal moisture stress and, thus give better grain yield. The yield components exhibited varying trends of association among themselves. Plant height showed positive significant correlations with kernel weight per main spike. The significant positive correlation of plant height with kernel weight has been reported by Ali et al. (2008). To evaluate the correlation between variables, it is important to know this "magnitude" or "strength" as well as the significance of the correlation. It expresses the amount of common variation between the two variables. The estimate of determination (R^2) indicates that the total variability accounted by all the characters considered together was 96 %, whereas 36 % of the total variability for yield per plant could be accounted if selection was based only on fertile tillers number and number of kernels per main spike indicating that more emphasis should be laid on the improvement of these two components for increasing the grain yield in barley.

5. Conclusion

The present study revealed that grain yield per plant had strong and positive genotypic correlation with fertile tillers number, and number of kernels per main spike. Multiple correlations indicated that the total variability accounted by these traits was 36.38 %. Regression analysis also indicated fertile tillers number and number of kernels per main spike as the most effective variables contributing to the grain yield. So, it is concluded that these two traits may be considered as the selection criteria for the improvement of grain barley.

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Table 1. Number, name / cross pedigree, seed source, source number, and FAO status of the genotypes

Entry No.	Name/Cross	Pedigree	Seed Source	Source No.	FAO Status*
1	Harmal	-	CHECK05	26	U
2	Tipper/ICB-102854//Alpha/Durra	ICB98-0441-0AP-6AP-0AP	BOLC06INC	2	U
3	MRYT169/Mamluk//YEA389-3/YEA475-4	ICB97-0098-0AP-0AP-7AP-0AP	BOLC06INC	3	U
4	Lignee131/ArabiAbiad//Mal1-4-3094-2	ICB92-0339-0AP-3AP-0AP-5AP-0AP	BOLC06INC	7	U
5	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-42AP-0AP	BOLC06INC	8	U
6	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-44AP-0AP	BOLC06INC	9	U
7	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-44AP-0AP	BOLC06INC	9	U
8	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-51AP-0AP	BOLC06INC	11	U
9	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-53AP-0AP	BOLC06INC	13	U
10	Matnan-01	-	CHECK05	27	U
11	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-57AP-0AP	BOLC06INC	14	U
12	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-78AP-0AP	BOLC06INC	16	U
13	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-85AP-0AP	BOLC06INC	17	U
14	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-86AP-0AP	BOLC06INC	18	U
15	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-90AP-0AP	BOLC06INC	19	U

16	WI2291/Roho//WI2269/3/Arta	ICB98-1035-0AP-93AP-0AP	BOLC06INC	20	U
17	SLB39-39/H.spont.41-5	ICB87-1011-62AP-1BO-0AP-2APH-2AP-0AP-4AP-0A-0AP-7A-0AP-0AP	BOLC06INC	24	U
18	SLB39-39/H.spont.41-5	ICB87-1011-62AP-1BO-0AP-2APH-2AP-0AP-4AP-0A-0AP-10-0AP-0AP	BOLC06INC	25	U
19	Arar/H.spont.19-15//Arta	ICB88-1271-19AP-5AP-1APH-0AP-4AP-0AP-7AP-0A-0AP-1A-0AP-0AP	BOLC06INC	26	U
20	National check	-	-	-	-
21	Arar/H.spont.19-15//Arta	ICB88-1271-19AP-5AP-1APH-0AP-4AP-0AP-7AP-0A-0AP-4A-0AP-0AP	BOLC06INC	27	U
22	Arar/H.spont.19-15//Arta	ICB88-1271-19AP-5AP-1APH-0AP-4AP-0AP-7AP-0A-0AP-5A-0AP-0AP	BOLC06INC	28	U
23	Arar/H.spont.19-15//Arta	ICB88-1271-19AP-5AP-1APH-0AP-4AP-0AP-7AP-0A-0AP-9A-0AP-0AP	BOLC06INC	29	U
24	Arar/H.spont.19-15//Arta	ICB88-1271-19AP-5AP-1APH-0AP-4AP-0AP-8AP-0A-0AP-7A-0AP-0AP	BOLC06INC	30	U
25	Moroc9-75/Harmal	ICB92-0809-47AP-0AP-10AP-0AP-0AP-6AP-0AP	BOLC06INC	31	U
26	Moroc9-75/Harmal	ICB92-0809-47AP-0AP-1AP-0AP-0AP-4AP-0AP	BOLC06INC	32	U
27	Moroc9-75/Harmal	ICB92-0809-47AP-0AP-1AP-0AP-0AP-12AP-0AP	BOLC06INC	33	U
28	H.spont.21-3//Arar84//WI2269/3/Sara	ICB93-0644-0AP-11AP-0AP-0AP-12AP-0AP	BOLC06INC	34	U
29	ArabiAbiad/WI2291//Tadmor/4/H.spont.93-4/3/Roho//Alger/Ceres362-1-1	ICB93-0690-0AP-19AP-0AP-0AP-8AP-0AP	BOLC06INC	35	U
30	Harmal	-	CHECK05	26	U
31	WI2291/Tipper	ICB93-1156-0AP-4AP-0AP-0AP-16AP-0AP	BOLC06INC	36	U
32	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	ICB94-0402-0AP-6A-0AP-0AP-8AP-0AP	BOLC06INC	38	U
33	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	ICB94-0402-0AP-6A-0AP-0AP-16AP-0AP	BOLC06INC	39	U
34	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	ICB94-0402-0AP-6A-0AP-0AP-19AP-0AP	BOLC06INC	40	U
35	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	ICB94-0402-0AP-7A-0AP-0AP-9AP-0AP	BOLC06INC	41	U
36	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	ICB94-0402-0AP-7A-0AP-0AP-10AP-0AP	BOLC06INC	42	U
37	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	ICB94-0402-0AP-7A-0AP-0AP-11AP-0AP	BOLC06INC	43	U
38	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	ICB94-0402-0AP-7A-0AP-0AP-12AP-0AP	BOLC06INC	44	U
39	Mo.B1337/WI2291//SlS/Akrash-02	ICB94-0654-0AP-10-0AP-0AP-12AP-0AP	BOLC06INC	46	U
40	Matnan-01	-	CHECK05	27	U

41	Akrash//WI2291/WI2269/3/Arar/19-3//WI2291	ICB94-0671-0AP-1A-0AP-0AP-20AP-0AP	BOLC06INC	47	U
42	ArabiAbiad/Arar/3/Arar/19-3//WI2291	ICB94-0681-0AP-5A-0AP-0AP-5AP-0AP	BOLC06INC	49	U
43	ArabiAbiad/Arar/3/Arar/19-3//WI2291	ICB94-0681-0AP-5A-0AP-0AP-6AP-0AP	BOLC06INC	50	U
44	Akrash//WI2291/WI2269/3/SIs/Akrash-02	ICB94-0644-0AP-41AP-0AP	BOLC06INC	54	U
45	H.spont.41-1/Tadmor/4/Gloria'S/Copal'S//Abn/3/Shyri	ICB97-0407-0AP-2AP-0AP	BOLC06INC	56	U
46	WI2269/Lignee131/3/SB73358-B-104-16-1-3//ER/Apm/5/ER/Apm//Lignee131/4/ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	ICB98-0981-0AP-3AP-0AP	BOLC06INC	57	U
47	WI2269/Lignee131/3/SB73358-B-104-16-1-3//ER/Apm/5/ER/Apm//Lignee131/4/ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	ICB98-0981-0AP-5AP-0AP	BOLC06INC	58	U
48	Mo.B1337/WI2291//Bonita/Weeah/5/ER/Apm/Lignee131/4/ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	ICB98-0990-0AP-4AP-0AP	BOLC06INC	59	U
49	SLB39-05/4/7028/2759/3/69-82//Ds/Apro	ICB87-0588-10BO-1APH-0TR-0AP-15AP-0AP-16AP-0AP	BOLC06INC	60	U
50	National_check	-	-	-	-
51	Viringa'S//Hml-02/ArabiAbiad*2	ICB92-1453-0AP-10AP-4TR-0AP	BOLC06INC	62	U
52	Moroc9-75//WI2291/CI01387/3/H.spont.41-1/Tadmor	ICB94-0342-38AP-0AP-7AP-2TR-0AP	BOLC06INC	63	U
53	ArabiAbiad/Arar//H.spont.41-5/Tadmor	ICB94-0358-12AP-0AP-4AP-1TR-0AP	BOLC06INC	64	U
54	ArabiAbiad/Arar//H.spont.41-5/Tadmor	ICB94-0358-12AP-0AP-7AP-4TR-0AP	BOLC06INC	66	U
55	Arta/Zabad	ICB97-0282-0AP-23AP-15TR-0AP	BOLC06INC	68	U
56	Arta/Zabad	ICB97-0282-0AP-23AP-18TR-0AP	BOLC06INC	69	U
57	SLB45-58/Arta/6//WI2291/Bgs/5/Cq/Cm//Apm/3/12410/4/Gizeh134-2L	ICB97-0385-0AP-25AP-14TR-0AP	BOLC06INC	70	U
58	Cerise/Lignee1479//Moroc9-75/PmB/3/JLB37-74/H.spont.41-5//JLB37-74/H.spont.41-5	ICB97-0402-0AP-11AP-2TR-0AP	BOLC06INC	71	U
59	Rum//Alanda/Hamra	ICB98-0726-0AP-16AP-0AP	BOLC06INC	73	U
60	Harmal	-	CHECK05	26	U
61	Rum//Alanda/Hamra	ICB98-0726-0AP-27AP-0AP	BOLC06INC	74	U
62	Rum//Alanda/Hamra	ICB98-0726-0AP-69AP-0AP	BOLC06INC	76	U
63	Rum//Alanda/Hamra	ICB98-0726-0AP-79AP-0AP	BOLC06INC	78	U
64	Rum//Alanda/Hamra	ICB98-0726-0AP-86AP-0AP	BOLC06INC	80	U
65	Rum//Alanda/Hamra	ICB98-0726-0AP-91AP-0AP	BOLC06INC	81	U
66	Rum//Alanda/Hamra	ICB98-0726-0AP-100AP-0AP	BOLC06INC	82	U
67	Rum/Manal	ICB98-0739-0AP-1AP-0AP	BOLC06INC	85	U
68	Rum/Manal	ICB98-0739-0AP-6AP-0AP	BOLC06INC	86	U
69	Beecher	Sel.7TR-1TR-0AP	BOLC06INC	87	-
70	Matnan-01	-	CHECK05	27	
71	Beecher	Sel.7TR-2TR-0AP	BOLC06INC	88	-
72	Beecher	Sel.12TR-3TR-0AP	BOLC06INC	89	-
73	Aths/Lignee686/4/Avt/Attiki//Aths/3/Giza121/Pue	ICB95-0315-0AP-1AP-0AP	BOLC06INC	91	U
74	Mari/Aths*2//Avt/Attiki/3/Aths/Lignee686/4/Manal	ICB96-0856-0AP-14AP-0AP	BOLC06INC	92	U
75	Mari/Aths*2//Avt/Attiki/3/Aths/Lignee686/4/Arar//Hr/Nopal	ICB96-0866-0AP-6AP-0AP	BOLC06INC	93	U
76	Acc#116132-Coll#89023-11/Malouh	ICB98-0433-0AP-11AP-0AP	BOLC06INC	96	U
77	Rhn-03/3/Api/CM67//Aths*3/4/Alanda-01	ICB98-0446-0AP-8AP-0AP	BOLC06INC	97	U

78	Lignee527/NK1272//Alanda/3/Arbayan-01//M6/Robur-35-6-3	ICB98-0817-0AP-13AP-0AP	BOLC06INC	98	U
79	Rhn-03//Arar/Lignee527	ICB98-0006-0AP-20AP-0AP	BOLC06INC	99	U
80	National check	-	-	-	-
81	Khardal/3/Lignee527/Chn-01//Asher/5/CompCr229//As46/Pro/3/Srs/4/Bda	ICB98-0027-0AP-18AP-0AP	BOLC06INC	100	U
82	80-5145/N-Acc4000-301-80//RWA-M54/6/Rhn-03/Asse/5/U.Sask.1766/Api/Cel/3/Weeah/4/Lignee527/NK1272	ICB98-0033-0AP-15AP-0AP	BOLC06INC	101	U
83	Rhn-03/3/Sutter//Sutter*2/Numar	ICB98-0056-0AP-1AP-0AP	BOLC06INC	102	U
84	Rhn-03/4/Rhn-08/3/DeirAlla106//DL71/Strain205	ICB98-0859-0AP-7AP-0AP	BOLC06INC	103	U
85	Centinela/2*Calicuchima/5/Alanda-02/4/Arizona5908/Aths//Asse/3/F208-74	ICB98-0922-0AP-1AP-0AP	BOLC06INC	105	U
86	Hamra//Lignee527/Rhn/3/Harra	ICB98-1221-0AP-4AP-0AP	BOLC06INC	107	U
87	Tunisia/3/Lignee527/Chn-01//Lignee527/NK1272	ICB98-1254-0AP-1AP-0AP	BOLC06INC	109	U
88	Alanda/Hamra//M192	ICB98-1210-0AP-3AP-0AP	BOLC06INC	110	U
89	Carina/WI2291//Tilga	ICB02-1000-0AP	BOLC06INC	111	U
90	Harmal	-	CHECK05	26	U
91	Carina/WI2291//WI3180	ICB02-1060-0AP	BOLC06INC	112	U
92	Arda/Quinn/5/Roho/4/Zanbaka/3/ER/Apm//Lignee131	ICB02-1126-0AP	BOLC06INC	113	U
93	Rhn-03//Lignee527/NK1272/3/Rum	ICB02-1509-0AP	BOLC06INC	115	U
94	Roho//Alger/Ceres362-1-1/3/Kantara/4/Bowman	ICB93-0791-10AP-0AP-19AP-0AP	BOM06INC	26	U
95	Zabad/5/Sfa-02/3/RM1508/Por//WI2269/4/Roho/Arabi Abiad	ICB96-0555-11AP-1TR-0AP	BOM06INC	36	U
96	Clipper//WI2291*2//WI2269	ICB97-0139-0AP-9AP-90TR-0AP	BOM06INC	44	U
97	Matnan-01	-	CHECK05	27	U
98	National check (Rum)	-	-	-	-

Note: U=Undesignated, D = Designated

Table 2. Distribution of rainfall and temperature regimes during the seasons

Month	Rainfall (mm)		Temperature° C	
	2005/2006	2006/2007	2005/2006	2006/2007
December	71.1	20.8	9.85	10.12
January	62.8	62.2	9.1	10.12
February	87.9	102.1	11.2	11.54
March	4.5	51.3	11.65	11.64
April	35.5	31	15.2	14.56
May	0	9.4	22.2	23.2
June	0	0	23.7	24.2
Total	261.8	276.8		

Table 3. Analysis of variance form applied for combined data of two seasons

Source of variation	df	MS	Expected MS
Season (s)	s-1	-	-
Rep. within season	s(r-1)	-	-
Cultivars (V)	g-1	MS1	$\sigma_e^2 + \sigma_{gs}^2 + sr \sigma_g^2$
V × S	(s-1)(g-1)	MS2	$\sigma_e^2 + r \sigma_{gs}^2$
Pooled error	S(r-1)(g-1)	MS3	σ_e^2

Table 4a. Analysis of variance for biological yield per plant, grain yield per plant (GY), harvest index per plant (HI), tiller number (TN), fertile tillers number (FTN), number of kernels per main spike (KN), thousand kernel weight (TKW), plant height (PH), heading date (HD), maturity date (MD) and grain filling period (GFP) of 86 barley genotypes grown under field conditions

Source of variance	Mean square							
	BY	GY	HI	TN	FTN	KN	TKW	PH
Season (S)	0.01	0.47	318.34	3**	2.08**	333.75**	16.52	449.31**
Rep. within season	34.68 **	7.68**	716.41**	7.82**	3.32**	6.03	4.35	40.61**
Cultivars (V)	15.76 **	3.77**	209.58**	1.50**	1.30**	661.52**	330.25**	635.93**
V × S	0.75	0.01	39.88	0.48	0.33	7.92	17.67	11.46
Pooled error	1.91	0.80	101.07	0.42	0.31	10.10	20.23	11.57

* Significant at the 0.05 probability level.

Table 4b. Analysis of variance for biological yield per plant, grain yield per plant (GY), harvest index per plant (HI), tiller number (TN), fertile tillers number (FTN), number of kernels per main spike (KN), thousand kernel weight (TKW), plant height (PH), heading date (HD), maturity date (MD) and grain filling period (GFP) of 86 barley genotypes grown under field conditions

Source of variance	Mean square		
	HD	MD	GFP
Season (S)	187.91**	848.88**	238.01**
Rep. within season	22.11 **	164.26**	84.86**
Cultivars (V)	138.06**	253.52**	177.33**
V × S	3.68	13.70	13.51
Pooled error	3.65	11.14	13.70

* Significant at the 0.05 probability level.

Table 5. Variation for 11 characters in 86 barley genotypes and mean values of check cultivars

Variable	Range	Mean±SE	Std Dev	F. values for genotype	LSD (P-0.05)	Check cultivars		
						Rum	Harmal	Matnan
BY	2.00-14.25	6.92±0.79	02.06	08.24**	01.57	6.66	6.32	7.59
GY	0.58-7.65	3.04±0.51	01.09	04.72**	01.02	2.99	2.78	3.41
HI	9.5-84.4	44.23±5.80	10.65	00.39**	11.42	44.88	44.35	45.94
TN	1-6	03.11±0.37	00.82	03.63**	00.73	02.75	03.38	03.00
FTN	1-5	02.47±0.32	00.71	04.28**	00.63	02.17	02.75	02.38
KN	10-59	29.62±1.83	10.86	65.45**	03.61	33.71	21.51	29.13
TKW	24.97-79.20	48.34±2.59	08.42	16.33**	05.11	50.79	51.44	45.44
PH	39-91	64.11±1.96	10.76	54.95**	03.87	62.25	66.33	61.83
HD	106-139	116.12±1.10	05.13	37.80**	02.17	116.75	112.25	119.04
MD	123-178	143.05±1.92	07.36	22.74**	03.79	141.92	140.79	148.17
GFP	12-48	26.93±2.14	06.44	13.74**	04.21	25.71	28.54	29.13

Table 6a. Mean values of grain yield components of examined genotypes of barley

Entry No.	Name	BY	GY	HI	TN	FTN	KN	KW
1	Harmal	05.31	2.62	49.39	2.67	2.67	18	48.72
2	Tipper/ICB-102854//Alpha/Durra	06.12	1.83	29.87	3.33	1.67	21	38.51
3	MRYT169/Mamluk//YEA389-3/YEA475-4	05.45	1.85	33.96	3.00	2.17	17	39.66
4	Lignee131/ArabiAbiad//Mal1-4-3094-2	04.31	01.72	39.95	1.67	1.67	17	28.63
5	WI2291/Roho//WI2269/3/Arta	06.85	03.06	44.68	3.67	2.67	25	49.06
6	WI2291/Roho//WI2269/3/Arta	06.83	02.48	36.37	3.00	2.67	21	37.21
7	WI2291/Roho//WI2269/3/Arta	06.46	2.31	35.75	3.33	2.33	15	49.05
8	WI2291/Roho//WI2269/3/Arta	06.13	3.11	50.73	3.33	2.50	23	59.11
9	WI2291/Roho//WI2269/3/Arta	03.77	02.20	58.22	3.00	2.17	15	52.04
10	Matnan-01	03.97	2.11	53.15	3.17	1.67	30	41.66
11	WI2291/Roho//WI2269/3/Arta	03.22	01.87	58.12	2.33	1.50	23	48.12
12	WI2291/Roho//WI2269/3/Arta	04.83	2.87	59.39	3.50	2.33	24	43.52
13	WI2291/Roho//WI2269/3/Arta	04.97	2.59	52.24	2.67	2.00	25	50.31
14	WI2291/Roho//WI2269/3/Arta	04.28	02.40	55.93	2.67	2.17	22	54.31
15	WI2291/Roho//WI2269/3/Arta	05.04	2.41	47.75	2.67	1.83	24	53.25
16	WI2291/Roho//WI2269/3/Arta	05.63	02.54	45.21	3.33	2.33	22	47.38
17	SLB39-39/H.spont.41-5	05.62	02.34	41.53	3.17	2.33	20	62.55
18	SLB39-39/H.spont.41-5	05.87	2.77	47.18	3.17	2.50	28	43.49
19	Arar/H.spont.19-15//Arta	05.73	2.94	51.34	4.17	3.33	24	38.80
20	National_check	05.77	2.75	47.58	2.67	1.50	36	52.19
21	Arar/H.spont.19-15//Arta	05.15	2.53	49.17	3.00	2.50	25	37.69
22	Arar/H.spont.19-15//Arta	05.11	2.64	51.75	2.83	2.17	25	46.64
23	Arar/H.spont.19-15//Arta	03.99	1.94	48.61	2.83	2.33	23	38.19
24	Arar/H.spont.19-15//Arta	05.21	2.12	40.59	2.83	2.33	23	37.54
25	Moroc9-75/Harmal	04.79	2.37	49.46	2.67	2.00	21	54.03
26	Moroc9-75/Harmal	08.08	3.37	41.68	3.50	3.17	22	56.79
27	Moroc9-75/Harmal	05.16	2.56	49.63	2.83	2.33	22	55.56
28	H.spont.21-3/Arar84//WI2269/3/Sara	07.51	2.74	36.43	4.00	3.00	22	50.46
29	ArabiAbiad/WI2291//Tadmor/4/H.spont.93-4/3/Roho //Alger/Ceres362-1-1	07.07	3.02	42.68	3.67	3.50	20	52.15
30	Harmal	06.61	2.90	43.81	3.67	2.83	22	55.72
31	WI2291/Tipper	06.70	2.76	41.15	3.50	2.67	25	50.46
32	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	06.38	2.98	46.68	2.83	2.50	21	54.03
33	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	06.36	2.59	40.79	3.00	2.17	22	52.29
34	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	06.86	2.77	40.38	2.67	2.17	24	49.37
35	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	05.45	02.28	41.89	3.00	2.17	23	48.50
36	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	06.89	2.68	38.95	3.83	3.33	25	42.74
37	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	05.15	2.36	45.87	2.83	2.17	24	44.45
38	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	07.69	3.83	49.74	3.50	2.83	24	49.39
39	Mo.B1337/WI2291//SlS/Akrash-02	07.23	3.33	45.99	3.17	2.50	22	57.97
40	Matnan-01	07.77	3.41	43.87	3.17	2.50	38	35.49
41	Akrash//WI2291/WI2269/3/Arar/19-3//WI2291	06.24	2.51	40.23	2.83	2.33	25	55.54
42	ArabiAbiad/Arar/3/Arar/19-3//WI2291	07.26	3.20	44.01	3.00	2.50	24	57.44
43	ArabiAbiad/Arar/3/Arar/19-3//WI2291	06.49	2.51	38.63	2.83	2.17	25	57.40
44	Akrash//WI2291/WI2269/3/SlS/Akrash-02	06.32	02.53	39.99	3.00	2.33	27	46.79
45	H.spont.41-1/Tadmor/4/Gloria'S'/Copal'S'//Abn/3/Shyri	05.11	2.09	40.81	2.67	2.17	16	36.11
46	WI2269/Lignee131/3/SB73358-B-104-16-1-3//ER/Apm/ 5/ER /Apm//Lignee131/4/ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	04.40	1.78	40.57	3.00	2.50	17	29.90
47	WI2269/Lignee131/3/SB73358-B-104-16-1-3//ER/Apm/5/ER /Apm//Lignee131/4/ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	05.28	2.15	40.62	2.50	2.17	22	41.53
48	Mo.B1337/WI2291//Bonita/Weeah/5/ER/Apm// Lignee131/4/ ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	05.85	2.62	44.82	2.67	2.17	23	63.57
49	SLB39-05/4/7028/2759/3/69-82//Ds/Apro	06.95	2.88	41.44	2.83	2.33	27	57.63

50	National check	06.77	02.93	43.22	2.67	2.33	37	47.77
51	Viringa'S//Hml-02/ArabiAbiad*2	07.97	2.69	33.76	3.00	2.00	23	49.53
52	Moroc9-75//WI2291/CI01387/3/H.spont.41-1/Tadmor	07.78	2.98	38.39	3.50	2.33	22	45.96
53	ArabiAbiad/Arar//H.spont.41-5/Tadmor	08.14	3.26	40.04	3.17	2.50	27	54.55
54	ArabiAbiad/Arar//H.spont.41-5/Tadmor	07.53	03.18	42.23	3.17	2.83	22	50.05
55	Arta/Zabad	08.64	04.08	47.27	4.50	3.33	22	61.55
56	Arta/Zabad	07.75	3.12	40.26	3.67	2.50	26	49.32
57	SLB45-58/Arta/6/WI2291/Bgs/5/Cq/Cm//Apm/ 3/12410/4/Gizeh134-2L	06.24	2.59	41.55	2.83	1.83	24	48.01
58	Cerise/Lignee1479//Moroc9-75/PmB/3/JLB37-74 /H.spont.41-5// JLB37-74/H.spont.41-5	07.17	2.88	40.16	3.17	2.33	18	55.47
59	Rum//Alanda/Hamra	08.74	4.31	49.29	2.83	2.17	52	52.06
60	Harmal	06.53	2.92	44.79	3.50	2.67	18	60.18
61	Rum//Alanda/Hamra	07.81	3.81	48.80	2.83	2.50	51	50.43
62	Rum//Alanda/Hamra	07.36	3.31	44.99	2.83	2.50	45	41.79
63	Rum//Alanda/Hamra	11.34	4.95	43.69	3.00	2.83	55	52.78
64	Rum//Alanda/Hamra	07.20	03.12	43.28	2.67	2.33	38	45.87
65	Rum//Alanda/Hamra	08.75	4.38	50.08	2.83	2.33	53	55.82
66	Rum//Alanda/Hamra	06.59	2.36	35.75	2.50	1.83	36	39.36
67	Rum/Manal	07.87	3.02	38.33	2.67	2.33	46	36.07
68	Rum/Manal	08.49	3.74	44.06	2.83	2.33	41	54.39
69	Beecher	07.68	3.24	42.14	2.67	2.33	43	40.74
70	Matnan-01	08.45	3.42	40.45	2.83	2.67	35	47.99
71	Beecher	08.42	3.86	45.87	3.33	2.33	35	59.55
72	Beecher	08.62	03.42	39.69	3.33	2.33	45	55.32
73	Aths/Lignee686/4/Avt/Attiki//Aths/3/Giza121/Pue	08.73	3.86	44.18	3.17	2.67	42	36.06
74	Mari/Aths*2//Avt/Attiki/3/Aths/Lignee686/4/Manal	07.99	2.38	29.85	3.17	2.17	45	38.57
75	Mari/Aths*2//Avt/Attiki/3/Aths/Lignee686/4/Arar//Hr/Nopal	08.57	03.83	44.68	3.33	2.67	45	43.41
76	Acc#116132-Coll#89023-11/Malouh	09.62	05.07	52.66	3.67	3.50	43	51.68
77	Rhn-03/3/Api/CM67//Aths*3/4/Alanda-01	06.79	03.41	50.20	3.00	2.67	40	46.24
78	Lignee527/NK1272//Alanda/3/Arbayan-01//M6/Robur-35-6-3	09.69	04.36	45.00	3.83	3.33	47	45.59
79	Rhn-03//Arar/Lignee527	10.69	04.97	46.53	3.00	2.17	45	42.80
80	National check	07.19	03.37	46.83	3.17	2.50	34	50.22
81	Khaldal/3/Lignee527/Chn-01//Asher/5/CompCr229// As46/Pro/3/Srs/4/Bda	10.30	4.42	42.92	3.33	2.50	46	50.80
82	80-5145/N-Acc4000-301-80//RWA-M54/6/Rhn-03/Asse/5/ U.Sask.1766/Api//Cel/3/Weeah/4/Lignee527/NK1272	07.35	02.31	31.40	2.33	1.50	32	47.94
83	Rhn-03/3/Sutter//Sutter*2/Numar	08.71	4.93	56.58	3.33	3.17	49	52.71
84	Rhn-03/4/Rhn-08/3/DeirAlla106//DL71/Strain205	09.15	4.73	51.70	3.83	3.00	46	46.17
85	Centinela/2*Calicuchima/5/Alanda-02/4/Arizona5908/ Aths//Asse/3/F208-74	09.60	4.72	49.22	3.33	2.83	48	46.52
86	Hamra//Lignee527/Rhn/3/Harra	07.41	03.03	40.87	3.17	2.83	43	41.94
87	Tunisia/3/Lignee527/Chn-01//Lignee527/NK1272	06.07	2.47	40.66	2.67	2.17	36	39.80
88	Alanda/Hamra//M192	06.08	2.86	47.05	2.33	2.17	37	42.87
89	Carina/WI2291//Tilga	09.11	04.21	46.20	5.00	4.00	24	49.73
90	Harmal	06.83	02.69	39.40	3.67	2.83	29	41.13
91	Carina/WI2291//WI3180	08.79	03.53	40.15	3.83	3.50	27	47.64
92	Arda/Quinn/5/Roho/4/Zanbaka/3/ER/Apm//Lignee131	06.12	02.64	43.09	3.33	2.17	22	63.06
93	Rhn-03//Lignee527/NK1272/3/Rum	06.29	02.55	40.49	2.00	2.00	33	57.03
94	Roho//Alger/Ceres362-1-1/3/Kantara/4/Bowman	08.37	03.69	44.13	4.00	3.00	25	40.68
95	Zabad/5/Sfa-02/3/RM1508/Por//WI2269/4/Roho/Arabi Abiad	07.65	03.39	44.34	3.33	3.17	24	49.86
96	Clipper//WI2291*2/WI2269	06.74	2.74	40.61	3.33	2.67	22	47.16
97	Matnan-01	10.14	4.69	46.28	2.83	2.67	53	56.63
98	National check	06.92	2.90	41.90	2.50	2.33	29	53.00

Table 6b. Mean values of grain yield components of examined genotypes of barley in Al-Huson Field Campus

Entry No.	Name	PH	HD	MD	GFP
1	Harmal	56.00	109.00	137.83	28.83
2	Tipper/ICB-102854//Alpha/Durra	47.00	131.67	158.67	27.00
3	MRYT169/Mamluk//YEA389-3/YEA475-4	45.50	136.83	160.83	24.00
4	Lignee131/ArabiAbiad//Mall-4-3094-2	44.00	135.67	163.00	27.33
5	WI2291/Roho//WI2269/3/Arta	51.00	113.00	142.33	29.33
6	WI2291/Roho//WI2269/3/Arta	52.67	117.00	142.33	25.33
7	WI2291/Roho//WI2269/3/Arta	53.00	111.17	127.67	16.50
8	WI2291/Roho//WI2269/3/Arta	54.33	114.50	136.50	22.00
9	WI2291/Roho//WI2269/3/Arta	45.00	114.00	134.33	20.33
10	Matnan-01	58.17	125.33	142.67	17.33
11	WI2291/Roho//WI2269/3/Arta	44.33	114.67	135.48	20.82
12	WI2291/Roho//WI2269/3/Arta	46.00	114.00	135.50	21.50
13	WI2291/Roho//WI2269/3/Arta	56.50	114.33	134.50	20.17
14	WI2291/Roho//WI2269/3/Arta	45.67	113.67	134.67	21.00
15	WI2291/Roho//WI2269/3/Arta	44.00	113.83	135.33	21.50
16	WI2291/Roho//WI2269/3/Arta	43.50	120.00	134.83	14.83
17	SLB39-39/H.spont.41-5	56.17	115.17	136.67	21.50
18	SLB39-39/H.spont.41-5	56.33	113.33	134.50	21.17
19	Arar/H.spont.19-15//Arta	52.67	113.83	133.50	19.67
20	National_check	57.17	118.00	135.00	17.00
21	Arar/H.spont.19-15//Arta	48.83	114.00	135.00	21.00
22	Arar/H.spont.19-15//Arta	53.67	112.05	129.67	17.62
23	Arar/H.spont.19-15//Arta	53.00	113.67	128.50	14.83
24	Arar/H.spont.19-15//Arta	54.00	113.55	131.17	17.62
25	Moroc9-75/Harmal	52.33	113.42	133.83	20.42
26	Moroc9-75/Harmal	69.50	114.17	137.83	23.67
27	Moroc9-75/Harmal	61.50	110.58	137.50	26.92
28	H.spont.21-3/Arar84//WI2269/3/Sara	58.50	131.33	148.83	17.50
29	ArabiAbiad/WI2291//Tadmor/4/H.spont.93-4/3/Roho//Alger /Ceres362-1-1	69.17	116.83	144.27	27.43
30	Harmal	72.67	113.33	142.33	29.00
31	WI2291/Tipper	66.33	121.50	141.50	20.00
32	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	67.50	114.00	142.67	28.67
33	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	69.67	115.00	141.83	26.83
34	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	75.83	114.83	140.50	25.67
35	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	73.17	114.17	140.83	26.67
36	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	67.50	113.83	141.67	27.83
37	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	62.50	112.83	139.33	26.50
38	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs	67.67	113.00	137.33	24.33
39	Mo.B1337/WI2291//SlS/Akrash-02	66.83	114.00	139.67	25.67
40	Matnan-01	56.17	118.00	144.83	26.83
41	Akrash//WI2291/WI2269/3/Arar/19-3//WI2291	62.50	114.72	140.67	25.95
42	ArabiAbiad/Arar/3/Arar/19-3//WI2291	77.00	119.00	144.50	25.50
43	ArabiAbiad/Arar/3/Arar/19-3//WI2291	71.17	116.83	145.00	28.17
44	Akrash//WI2291/WI2269/3/SlS/Akrash-02	61.83	116.17	148.00	31.83
45	H.spont.41-1/Tadmor/4/Gloria'S/Copal'S//Abn/3/Shyri	55.50	124.83	150.67	25.83
46	WI2269/Lignee131/3/SB73358-B-104-16-1-3//ER/Apm/ 5/ER/Apm //Lignee131/4/ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	40.50	126.17	151.50	25.33
47	WI2269/Lignee131/3/SB73358-B-104-16-1-3//ER/Apm/5/ER/Apm //Lignee131/4/ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	54.33	128.58	146.33	17.75
48	Mo.B1337/WI2291//Bonita/Weeah/5/ER/Apm//Lignee131/4/ ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	58.83	115.00	144.67	29.67

49	SLB39-05/4/7028/2759/3/69-82//Ds/Apro	67.50	115.67	139.67	24.00
50	National check	64.33	116.83	145.00	28.17
51	Viringa'S'//Hml-02/ArabiAbiad*2	75.83	114.33	139.83	25.50
52	Moroc9-75//WI2291/CI01387/3/H.spont.41-1/Tadmor	82.33	114.00	140.00	26.00
53	ArabiAbiad/Arar//H.spont.41-5/Tadmor	84.17	114.00	139.83	25.83
54	ArabiAbiad/Arar//H.spont.41-5/Tadmor	85.83	113.33	140.00	26.67
55	Arta/Zabad	65.33	113.33	142.17	28.83
56	Arta/Zabad	66.83	114.00	143.67	29.67
57	SLB45-58/Arta/6//WI2291/Bgs/5/Cq/Cm//Apm /3/12410/4/Gizeh134-2L	72.00	114.17	149.00	34.83
58	Cerise/Lignee1479//Moroc9-75/PmB/3/JLB37-74/ H.spont.41-5// JLB37-74/H.spont.41-5	73.50	109.83	142.50	32.67
59	Rum//Alanda/Hamra	66.17	113.67	150.67	37.00
60	Harmal	68.17	111.33	142.50	31.17
61	Rum//Alanda/Hamra	59.17	113.00	151.83	38.83
62	Rum//Alanda/Hamra	67.17	113.67	146.17	32.50
63	Rum//Alanda/Hamra	73.33	113.50	150.17	36.67
64	Rum//Alanda/Hamra	74.00	115.00	149.50	34.50
65	Rum//Alanda/Hamra	73.17	114.33	148.67	34.33
66	Rum//Alanda/Hamra	71.50	115.33	145.33	30.00
67	Rum/Manal	74.83	114.67	148.17	33.50
68	Rum/Manal	70.33	113.83	148.33	34.50
69	Beecher	74.67	115.83	145.17	29.33
70	Matnan-01	71.67	116.50	148.17	31.67
71	Beecher	75.67	115.67	144.33	28.67
72	Beecher	78.00	113.83	150.00	36.17
73	Aths/Lignee686/4/Avt/Attiki//Aths/3/Giza121/Pue	79.67	114.83	142.67	27.83
74	Mari/Aths*2//Avt/Attiki/3/Aths/Lignee686/4/Manal	79.50	116.17	147.17	31.00
75	Mari/Aths*2//Avt/Attiki/3/Aths/Lignee686/4/Arar//Hr/Nopal	69.33	116.83	141.50	24.67
76	Acc#116132-Coll#89023-11/Malouh	72.00	113.33	142.50	29.17
77	Rhn-03/3/Api/CM67//Aths*3/4/Alanda-01	69.33	113.83	140.00	26.17
78	Lignee527/NK1272//Alanda/3/Arbayan-01//M6/Robur-35-6-3	63.83	116.50	144.50	28.00
79	Rhn-03//Arar/Lignee527	76.33	114.67	144.33	29.67
80	National_check	60.50	115.00	143.83	28.83
81	Khardal/3/Lignee527/Chn-01//Asher/5/CompCr229//As46/Pro /3/Srs/4/Bda	75.50	116.00	143.67	27.67
82	80-5145/N-Acc4000-301-80//RWA-M54/6/Rhn-03/Asse/5/ U.Sask.1766/Api//Cel/3/Weeah/4/Lignee527/NK1272	59.67	116.83	145.00	28.17
83	Rhn-03/3/Sutter//Sutter*2/Numar	69.17	116.33	150.83	34.50
84	Rhn-03/4/Rhn-08/3/DeirAlla106//DL71/Strain205	72.67	117.83	151.50	33.67
85	Centinela/2*Calicuchima/5/Alanda-02/4/Arizona5908/Aths //Asse/3/F208-74	67.00	120.83	146.83	26.00
86	Hamra//Lignee527/Rhn/3/Harra	66.17	117.33	151.00	33.67
87	Tunisia/3/Lignee527/Chn-01//Lignee527/NK1272	68.17	115.67	146.50	30.83
88	Alanda/Hamra/M192	64.83	115.50	141.67	26.17
89	Carina/WI2291//Tilga	65.00	117.17	146.83	29.67
90	Harmal	68.50	115.33	140.50	25.17
91	Carina/WI2291//WI3180	70.17	117.67	150.00	32.33
92	Arda/Quinn/5/Roho/4/Zanbaka/3/ER/Apm//Lignee131	73.00	116.33	145.00	28.67
93	Rhn-03//Lignee527/NK1272/3/Rum	68.67	114.33	149.00	34.67
94	Roho//Alger/Ceres362-1-1/3/Kantara/4/Bowman	65.83	114.83	141.67	26.83
95	Zabad/5/Sfa-02/3/RM1508/Por//WI2269/4/Roho/Arabi Abiad	68.33	112.67	142.17	29.50
96	Clipper//WI2291*2/WI2269	68.33	115.67	141.67	26.00
97	Matnan-01	61.33	116.33	157.00	40.67
98	National_check	67.00	117.17	143.83	26.67

Table 7a. Genetic parameters for some characteristics in barley genotypes grown during two seasons 2005 /2006 and 2007 /2008 under field conditions

Source of variance	Mean square							
	BY	GY	HI	TN	FTN	KN	TKW	PH
σ^2_g	2.50	0.63	28.28	0.17	0.16	108.93	52.10	104.08
σ^2_{ph}	2.63	0.63	34.93	0.25	0.22	110.25	55.04	105.99
Heritability %	95.24	99.73	80.97	68.00	74.62	98.80	94.65	98.20
GCV (%)	22.86	26.04	12.02	13.26	16.28	35.24	14.93	15.91
PCV (%)	23.42	26.07	13.36	16.08	18.85	35.45	15.35	16.06
GA	3.18	1.63	9.86	0.70	0.72	21.37	14.47	20.83
GAM	45.95	53.57	22.29	22.52	28.97	72.15	29.92	32.48

* Significant at the 0.05 probability level.

Table 7b. Genetic parameters for some characteristics in barley genotypes grown during two seasons 2005 /2006 and 2007 / 2008 under field conditions

Source of variance	Mean square		
	HD	MD	GFP
σ^2_G	22.40	39.97	27.30
σ^2_P	23.01	42.25	29.56
Heritability %	97.33	94.60	92.38
GCV (%)	4.08	4.42	19.40
PCV (%)	4.13	4.54	20.19
GA	9.62	12.67	10.35
GAM	8.28	8.85	38.42

* Significant at the 0.05 probability level.

Table 8. Genotypic (Bold) and phenotypic correlations among different quantitative characters in barley

	BY	GY	HI	TN	FTN	KN	TKW	PH	HD	MD	GFP
BY	1	0.92 **	-0.22 **	0.39 **	0.60 **	0.71 **	0.18 **	0.71 **	-0.16 **	0.42 **	0.66 **
GY	0.78**	1	0.17 **	0.48	0.68 **	0.77 **	0.27 **	0.55 **	-0.30 **	0.26 **	0.60 **
HI	-0.11 **	0.49 **	1	0.05 **	0.14 **	0.14 **	0.29 **	-0.34 **	-0.51 **	-0.53 **	-0.18 **
TN	0.34 **	0.31 **	0.03	1	0.92 **	-0.08 **	0.16 **	0.19 **	-0.09 **	-0.09 **	-0.02 **
FTN	0.31 **	0.33 **	0.08 *	0.56 **	1	0.12 **	0.10 **	0.29 **	-0.20 **	0.05 **	0.24 **
KN	0.53 **	0.52 **	0.08	-0.03	0.07	1	-0.06 **	0.42 **	-0.13 **	0.40 **	0.60 **
TKW	0.15 **	0.33 **	0.15 **	0.04	0.03	-0.04	1	0.27 **	-0.41 **	-0.16 **	0.17 **
PH	0.50 **	0.35 **	-0.11 **	0.09 **	0.18 **	0.38 **	0.22 **	1	-0.34 **	0.20 **	0.56 **
HD	-0.12 **	0.15 **	-0.18 **	-0.03	-0.09 **	-0.10 **	-0.33 **	-0.28 **	1	0.59 **	-0.19**
MD	0.28 **	0.15 **	-0.20 **	-0.02	0.006	0.33 **	-0.13 **	0.17 **	0.51 **	1	0.68 **
GFP	0.41 **	0.31 **	-0.09 **	-0.01	0.08	0.46 **	0.12 **	0.42 **	-0.21	0.73 **	1

*, ** Significant at 0.05 and 0.01 level, respectively .

Table 9. Multiple correlation analysis of grain yield per plant on the basis of all yield components (Col. 1) and on the basis of fertile tillers number and number of kernels per main spike (Col. 2)

	Col. 1	Col. 2
Multiple correlation		
Coefficient of determination (R^2)	0.9635	0.3638
Adjusted R-square	0.9629	0.3616
Standard error	0.2214	0.8773

** Significant at 0.01 Level

Table 10a. Partial regression analysis of grain yield with its components in barley genotypes

Yield component	Partial regression coefficient (B)	S.E (B)	“ t”
Fertile tiller number	0.0584 **	0.01534	3.81
Number of kernel per main spike	0.00244*	0.00109	2.24
Thousand kernel weight	0.00004	0.00115	0.41
Plant height	-0.0008	0.0010	-0.81
Heading date	0.0038 *	0.0016	2.32
Maturity date	0.0030	0.0023	1.27

*, ** Significant at 0.05 and 0.01 level, respectively.

Table 10b. Partial regression analysis of grain yield with fertile tillers number and number of kernels per main spike in barley genotypes

Yield component	Partial regression coefficient (B)	S.E (B)	“ t”
Fertile tiller number	0.470**	0.0514	9.15
Number of kernel per main spike	0.050 **	0.003	15.13

*, ** Significant at 0.05 and 0.01 level, respectively.