ESTIMATION OF SOME GENETIC PARAMETERS FOR EARLINESS AND SOME VEGETATIVE TRAITS IN SOME HULLESS BARLEY GENOTYPES UNDER NORMAL AND WATER STRESS CONDITIONS

Abdel-Moneam, M. A.1; M. S. Sultan1; A. A. Eid2 and Sally E. El-Wakeel2

1Agronomy Dept., Fac. Agric., Mansoura Univ. Egypt
2Barley Dept., Field Crops Res. Institute, ARC, Egypt
E-mail: maaelmoneam@mans.edu.eg

ABSTRACT

This investigation was carried out at Sakha Agricultural Research Station, ARC, Egypt during the two growing seasons (2010/2011 and 2011/2012). Seven lines and three testers were used to develop barley hybrids for earliness and vegetative traits under normal and water stress conditions. Data revealed that most of the variances due to genotypes, parents, crosses, parents x crosses, lines, testers and line x testers were highly significant for most studied traits under both conditions and their combined data. The water stress treatment decreased the mean of days to heading for parents and their hybrids. The parental Line-1, Tester-1 under all conditions and top cross no. 7 under normal and combined and cross no. 1 under stress were the earliest parents and crosses for days to heading. The stressed genotypes for water, matured earlier than genotypes grown under normal condition. The ratios of GCA/SCA were lesser than unity for all studied traits under all conditions, which mean that non-additive gene effects played an important role in the inheritance of these traits. In such cases, a bulk method would be fruitful to eliminate the effect of dominance in the advanced generation. Desirable significant GCA effects were showed by Line-1 under water stress and Tester-1 under all conditions for days to heading; Tester-1 under normal and combined for days to maturity; Line-2 under stress and Line-7 under normal condition for grain filling period; Line-4, Line-6 under both conditions and combined, Line-3 under normal, Line-7 under water stress, Tester-3 under both conditions and combined data for grain filling rate; Line-4 under both conditions and their combined data, Line-7 under water stress and combined data, Tester-2 under stress and combined data for flag leaf area; and Line-3 under normal, Line-2 and Line-7 under water stress for total chlorophyll content. Moderate phenotypic and genotypic coefficients of variability were obtained for grain filling rate and total chlorophyll content, and high for flag leaf area. Small differences between genotypic and phenotypic coefficients of variability were found for all studied traits under all conditions, indicating the presence of sufficient genetic variability for these traits, which may facilitate selection. Broad sense heritability percentages ranged from moderate to high with percentages ranged from 10.82% for days to maturity at combined data to 97.30% for grain filling rate under normal condition. These results indicate that genotypic variances played the major part of phenotypic variances. Narrow sense heritability percentages varied from low to moderate with percentages ranged from 0.92% for grain filling period at combined data to 18.92% for grain filling rate under normal condition. The expected genetic advance (Δg) ranged from 0.02 for grain filling period at combined data to 0.36 for total chlorophyll content under normal condition. While, the estimates of predicted genetic advance (Δg %) ranged from 0.04% for grain filling period at combined data to 7.41% for grain filling rate under stress condition. Generally, traits that showed high values of narrow sense heritability and expected genetic advance from selection should be used in breeding program where selection in the early segregating generations will be useful because additive gene action is more important than non-additive genetic components.

Key words: Barley, Combining ability, Heritability, Genetic advance, Water stress.
INTRODUCTION

Barley (Hordeum vulgare L.) has a great adaptation potential in many regions of the world. It has a good tolerance to biotic stresses such as salinity, drought, frost and heat. It is considered one of the most important crops ranking the fourth in the world cereal crops production. Its economic importance is due to its usage for animal feeding, brewing malts and human food in some areas. In Egypt, barley is mainly used as animal feed (grain and straw) and sometimes for bread making by Bedouins. Barley is the dominant cereal crop grown in North West Coast and North Sinai in Egypt. It is grown also in the new reclaimed lands. Most of these lands are suffering from water shortage and low soil fertility. Development of barley cultivars having the ability to grow well under drought and the other environmental stresses is needed. An additional avenue is cultivation of the early maturing barley cultivars before cotton, to support the wheat production in Egypt for bread making to overcome the gap between wheat consumption and wheat production. Because barley production areas are located in different environments, developing stable barley cultivars is one of the main objectives for barley breeders. The ability of a cultivar to produce high and satisfactory yield under a wide range of stress and non-stress environments is very important. Finlay (1968) believed that stability over environments and yield potential are more or less independent of each other. Blum (1979) suggested that one method of breeding for increased performance under water stressed conditions might be to breed for superior yield under optimum conditions on the assumption that the best lines would also perform well under sub optimum conditions. Sharma et al. (2003) evaluated F₁ and F₂ in combining ability analysis, undertaken in 10 x 10 half-diallel progenies in barley for days to heading and flag leaf area, and they found that general combining ability (GCA) and specific combining ability (SCA) components of variance were significant for these traits. Mahmoud, Badea (2006) carried out a diallel analysis of combining ability for days to heading, days to maturity in barley, and she found that highly significant or significant positive and negative general combining ability estimates were obtained for days to heading, days to maturity and specific combining ability estimates were insignificant for these traits. While, Mansour (2007) studied days to heading, days to maturity and flag leaf area, and indicated that general and specific combining ability mean squares were highly significant for all the studied traits., and GCA /SCA ratios of studied traits were higher than unity, indicating the importance of additive genetic variance rather than non-additive in controlling the inheritance of these traits. Also, significant or highly significant and positive or negative GCA and SCA effects were detected for all the studied traits, indicating the important role of both additive and non-additive effects. And he added that heritability values in broad sense were high in all crosses. On the other hand, heritability values in narrow sense were low to moderate for all studied traits. Eshghi and Akhundova (2009), estimated narrow-sense heritability as 0.93 for days to maturity in the cross one, and 0.92 in the second cross. While, Blum (1979) suggested that one method of breeding for increased performance under water stressed conditions might be to breed for superior yield under optimum conditions on the assumption that the best lines would also perform well under sub optimum conditions. Sharma et al. (2003) evaluated F₁ and F₂ in combining ability analysis, undertaken in 10 x 10 half-diallel progenies in barley for days to heading and flag leaf area, and they found that general combining ability (GCA) and specific combining ability (SCA) components of variance were significant for these traits. Mahmoud, Badea (2006) carried out a diallel analysis of combining ability for days to heading, days to maturity in barley, and she found that highly significant or significant positive and negative general combining ability estimates were obtained for days to heading, days to maturity and specific combining ability estimates were insignificant for these traits. While, Mansour (2007) studied days to heading, days to maturity and flag leaf area, and indicated that general and specific combining ability mean squares were highly significant for all the studied traits., and GCA /SCA ratios of studied traits were higher than unity, indicating the importance of additive genetic variance rather than non-additive in controlling the inheritance of these traits. Also, significant or highly significant and positive or negative GCA and SCA effects were detected for all the studied traits, indicating the important role of both additive and non-additive effects. And he added that heritability values in broad sense were high in all crosses. On the other hand, heritability values in narrow sense were low to moderate for all studied traits. Eshghi and Akhundova (2009), estimated narrow-sense heritability as 0.93 for days to maturity in the cross one, and 0.92 in the second cross. Therefore, the main objectives of this study were estimation of combining ability effects, heritability and genetic advance from selection for earliness and some vegetative traits under normal and water stress conditions.

MATERIALS AND METHODS

The present investigation was carried out at the experimental farm of Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt, during the two successive seasons 2010/2011 and 2011/2012. Seven barley lines; L₁, L₂, L₃, L₄, L₅, L₆ and L₇ and three testers T₁ (Giza 129), T₂ (Giza 130) and T₃ (Giza 131) of hulless barley were used, the names and pedigrees of these genotypes are presented in Table (1).

Table (1): Names and pedigrees of parental barley genotypes.

| Lines | Genotypes | Pedigree |
|-------|-----------|----------|
| 1 L₁ (Line-1) | CONGONA/3/ATACO/BERMEJO/HIGO/4/PETUNIA 1 |
| 2 L₂ (Line-2) | LIGNEE640/P1382798/DC-B/3/MOLA/4/LION/10/CLN-B/7/S.P-B/LIGNEE640/6/S.P-B/5/GLORIA-BAR/4/SOTOL/2762/BC-B/3/11012.2/TERN-B/1/H272/6/FALCON-BAR/9/LION/11/PETUNIA 1 |
| 3 L₃ (Line-3) | CLN-B/80.5138//GLORIA-BAR/COPAL/3/CERRAJA |
| 4 L₄ (Line-4) | CONGONA/3/ATACO/ACHIRA/HIGO/7/ZARZA/5/GLORIA-BAR/4/SOTOL/2762/BC-B/3/11012.2/TERN-B/1/H272/6/SEN |
| 5 L₅ (Line-5) | PETUNIA 2 |
| 6 L₆ (Line-6) | ALANDA/LIGNEE527//ARAR/3/BF891M-653 |
| 7 L₇ (Line-7) | BF891M-597 |
| Testers | |
| 1 T₁ (Giza 129) | Local Variety |
| 2 T₂ (Giza 130) | Local Variety |
| 3 T₃ (Giza 131) | Local Variety |
In 2010/2011 season, the three testers were crossed with the seven lines to produce F1 hybrids of 21 top crosses. In 2011/2012 season, 21 F1 hybrids, three testers and seven lines were planted in two experiments. The first experiment was given planting irrigation only (water stress condition, S). The second was irrigated three times after planting irrigation (normal condition, N). Each experiment was designated in a randomized complete block design with three replicates. Each parent and F1 was represented by two rows per replicate. Each row was 1.5 m long, and spaces between rows were 30 cm with 15 cm between plants. All the recommended agronomic practices for barley production were applied at the proper time.

The studied traits: The following characters were recorded for ten guarded plants chosen randomly per row in each replicate:

1-Days to heading, DH (day): Number of days from sowing to the date in which the first spike begins the emergence from the flag leaf.

2-Days to maturity, DM (day): Number of days from sowing date to the day in which the main spike of studied plant reached to the physiological maturity.

3-Grain filling period (day): Number of days from heading to physiological maturity.

4-Grain filling rate (g/day): Determined by dividing the harvested grain weight by the duration of the grain filling period.

5-Flag leaf area, LA (cm²): Determined by measuring the flag leaf area to main stem by leaf area meter.

6-Total chlorophyll content (SPAD value): was determined by measuring the flag leaf total chlorophyll content by using analytical apparatus; chlorophyll meter (Model SPAD-502) Minolta Camera Co. Ltd, Japan.

Statistical analysis:
A regular analysis of variance of a randomized complete block design was conducted. If the differences among genotypes, crosses and their parents being significant, Line x tester analysis was performed according to Kempthorne (1957) and Singh and Chaudhary (1977). Heritability in broad (H²) and narrow (h²) senses were calculated according to Allard (1960) and Mather (1949). The phenotypic and genotypic coefficients of variation were estimated using the formulae developed by Burton (1952). Expected (Δg) and predicted Δg (%) genetic advance calculated as suggested by Borthakur and Poehllman (1970).

RESULTS AND DISCUSSION

Mean squares of different hulless barley genotypes for all studied characters in each environment are presented in Table (2). Statistical analysis revealed highly significant effects of genotypes under the two conditions and their combined for all the studied traits, providing evidence for presence of large amount of genetic variability, which considered adequate for further biometrical assessment. Significant or highly significant differences for all studied traits were found among the parents at the two conditions and their combined, except total chlorophyll content under normal and combined. Meanwhile, significant or highly significant differences of crosses mean squares were detected for all studied traits at the two conditions and their combined, except total chlorophyll content under normal and combined. The phenotypic and genotypic coefficients of variation were estimated using the formulae developed by Burton (1952). Expected (Δg) and predicted Δg (%) genetic advance calculated as suggested by Borthakur and Poehllman (1970).

Mean performance of genotypes:

Means performance of the seven lines, three barley testers and their F1 crosses at stress and normal irrigation conditions and their combined for all studied traits are presented in Tables (3, 4 and 5). The water stress treatment decreased the mean of days to heading for parents and their hybrids (Table 3). The parental line 1, tester 1 under all conditions and top cross no. 7 under normal and combined and cross no. 1 under stress were the earliest parents and crosses for days to heading. The stressed genotypes for water, matured earlier than genotypes grown under normal condition (Table 3). Farhat (2005) reached to similar conclusions and observed earlier maturity at water stress condition. Among parents, line 2 and line 7 under normal and line 7 under combined, line 5 under stress for lines, tester 1 under all conditions for testers and top cross no. 4 under stress and combined and cross 13 under normal were the earliest parents and crosses for days to maturity. On the other hand, the parental lines 4, 5 under normal, line 3 under stress and combined, tester 3 under all conditions and top cross 15 under normal and combined and cross 11 under stress were the latest parents and crosses for days to maturity.

Data in (Table 4) indicated that, the parental line 7 under all conditions for lines, tester 3 under normal and combined, tester 2 under stress for testers and top cross 6 under stress and combined and cross 13 under normal showed the lowest values for grain filling period.
The water stress treatment decreased the mean of grain filling rate for parents and their hybrids (Table 4). The parental line 7 under stress and combined, line 6 under normal, tester 3 under all conditions and top cross 13 under normal and cross 17 under stress and combined were the highest parents and crosses for grain filling rate.

Table (2): Observed mean squares from ordinary analysis of variance for the studied traits under normal, stress and their combined analysis during 2011/2012 season.

| S.O.V    | df | Days to heading (day) | Days to maturity (day) |
|----------|----|-----------------------|------------------------|
|          |    | Single | Comb. | Normal | Stress | Comb. | Normal | Stress | Comb. | Normal | Stress | Comb. |
| Rep.     | 2  | 5      | 2.79  | 12.59**| 615.84**| 5.45**| 5.26**| 282.59**|
| Genotypes| 30 | 30     | 10.54**| 11.20**| 16.68**| 4.95**| 11.08**| 12.62**|
| Parents (P) | 9  | 9      | 16.55**| 7.62** | 19.71**| 1.57**| 5.96**| 5.44**|
| Crosses (C) | 20 | 20     | 5.53**| 6.72** | 7.08** | 4.33**| 1.79**| 2.79**|
| P vs. C  | 1  | 1      | 56.56**| 133.05**| 181.56**| 47.68**| 243.12**| 273.76**|
| Lines (L) | 6  | 6      | 1.80  | 4.22*  | 3.66   | 1.40  | 1.07*  | 0.77   |
| Testers (T) | 2  | 2      | 25.54**| 6.02*  | 26.96**| 22.11**| 0.97*  | 16.74**|
| L x T    | 12 | 12     | 4.06**| 8.09** | 5.47** | 2.83**| 2.28**| 1.48   |
| Error    | 60 | 150    | 1.52  | 1.43   | 2.19   | 0.75  | 0.97   | 1.71   |

| S.O.V    | df | Grain filling period (day) | Grain filling rate (g/day) |
|----------|----|-----------------------------|-----------------------------|
|          |    | Single | Comb. | Normal | Stress | Comb. | Normal | Stress | Comb. | Normal | Stress | Comb. |
| Rep.     | 2  | 5      | 0.87**| 2.11   | 67.33**| 0.07**| 0.28**| 1.16**|
| Genotypes| 30 | 30     | 5.84**| 6.91** | 9.99** | 0.15**| 0.13**| 0.21**|
| Parents (P) | 9  | 9      | 13.63**| 13.19**| 24.19**| 0.08**| 0.04**| 0.09**|
| Crosses (C) | 20 | 20     | 2.62**| 3.60** | 3.63** | 0.10**| 0.11**| 0.13**|
| P vs. C  | 1  | 1      | 0.08  | 16.46**| 9.43** | 1.91**| 1.22**| 3.09**|
| Lines (L) | 6  | 6      | 1.59  | 5.04** | 3.31** | 0.11**| 0.18**| 0.18**|
| Testers (T) | 2  | 2      | 2.21  | 4.00** | 3.01   | 0.11**| 0.06**| 0.16**|
| L x T    | 12 | 12     | 3.21**| 2.82** | 3.89** | 0.09**| 0.09**| 0.10**|
| Error    | 60 | 150    | 0.771 | 0.774 | 1.169 | 0.003 | 0.003 | 0.015 |

| S.O.V    | df | Flag leaf area (cm²) | Total chlorophyll content |
|----------|----|----------------------|---------------------------|
|          |    | Single | Comb. | Normal | Stress | Comb. | Normal | Stress | Comb. | Normal | Stress | Comb. |
| Rep.     | 2  | 5      | 0.49  | 1.76   | 7.90** | 46.72**| 20.01**| 77.96**|
| Genotypes| 30 | 30     | 13.23**| 8.99** | 20.65**| 41.90**| 29.37**| 39.52**|
| Parents (P) | 9  | 9      | 24.52**| 14.52**| 27.18**| 26.63 | 19.79**| 25.76 |
| Crosses (C) | 20 | 20     | 5.83**| 5.02** | 11.57**| 50.79**| 24.87**| 41.65**|
| P vs. C  | 1  | 1      | 59.58**| 38.76**| 143.45**| 1.46 | 205.55**| 120.83**|
| Lines (L) | 6  | 6      | 4.33**| 6.40** | 7.18** | 61.28**| 41.37**| 56.58**|
| Testers (T) | 2  | 2      | 6.34**| 10.28**| 34.39**| 78.50**| 13.41**| 46.43**|
| L x T    | 12 | 12     | 6.50**| 3.45** | 9.96** | 40.93**| 18.54**| 33.39**|
| Error    | 60 | 150    | 0.85  | 0.74   | 1.09   | 19.27 | 4.23   | 15.75 |

*and **, indicate significant at 0.05 and 0.01 levels of probability, respectively.
Table (3): Means of lines, testers and their F₁ crosses for days to heading and days to maturity under normal, water stress and their combined data during 2011/2012 season.

| Genotypes | Days to heading (day) | Days to maturity (day) |
|-----------|-----------------------|------------------------|
|           | Normal | Stress | Comb. | Normal | Stress | Comb. |
| Line-1    | 96.33  | 89.33  | 92.83 | 132.00 | 126.33 | 129.17 |
| Line-2    | 99.00  | 91.00  | 95.00 | 131.33 | 126.00 | 128.67 |
| Line-3    | 97.00  | 89.67  | 93.34 | 132.67 | 128.00 | 130.34 |
| Line-4    | 101.00 | 91.00  | 96.00 | 133.00 | 125.67 | 129.34 |
| Line-5    | 101.67 | 91.33  | 96.50 | 133.00 | 124.67 | 128.84 |
| Line-6    | 98.67  | 90.00  | 94.34 | 131.67 | 126.00 | 128.84 |
| Line-7    | 102.00 | 94.33  | 98.17 | 131.33 | 125.00 | 128.17 |
| Tester-1 (Giza 129) | 97.00 | 88.33  | 92.67 | 131.00 | 122.67 | 126.84 |
| Tester-2 (Giza 130) | 97.67 | 90.67  | 94.17 | 131.00 | 124.33 | 127.67 |
| Tester-3 (Giza 131) | 102.67 | 90.33  | 96.50 | 132.67 | 125.00 | 128.84 |
| 1 L₁ x T₁ | 101.00 | 91.00  | 96.00 | 133.00 | 127.67 | 130.34 |
| 2 L₁ x T₂ | 99.33  | 92.33  | 95.83 | 133.33 | 129.33 | 131.33 |
| 3 L₁ x T₃ | 102.00 | 93.33  | 97.67 | 134.67 | 128.67 | 131.67 |
| 4 L₂ x T₁ | 99.67  | 91.33  | 95.50 | 133.00 | 127.33 | 130.17 |
| 5 L₂ x T₂ | 100.67 | 93.33  | 97.00 | 134.00 | 128.33 | 131.17 |
| 6 L₂ x T₃ | 100.67 | 96.67  | 98.67 | 133.67 | 129.00 | 131.34 |
| 7 L₃ x T₁ | 97.67  | 92.00  | 94.84 | 132.33 | 128.67 | 130.50 |
| 8 L₃ x T₂ | 101.00 | 93.67  | 97.34 | 134.00 | 129.67 | 131.84 |
| 9 L₃ x T₃ | 102.67 | 92.33  | 97.50 | 134.67 | 128.33 | 131.50 |
| 10 L₄ x T₁ | 99.33 | 93.33  | 96.33 | 132.33 | 129.67 | 131.00 |
| 11 L₄ x T₂ | 102.00 | 96.33  | 99.17 | 134.00 | 130.33 | 132.17 |
| 12 L₄ x T₃ | 103.00 | 91.33  | 97.17 | 135.00 | 127.67 | 131.34 |
| 13 L₅ x T₁ | 101.00 | 92.67  | 96.84 | 131.67 | 129.33 | 130.50 |
| 14 L₅ x T₂ | 100.00 | 91.67  | 95.84 | 133.33 | 128.33 | 130.83 |
| 15 L₅ x T₃ | 102.67 | 93.00  | 97.84 | 136.67 | 129.33 | 133.00 |
| 16 L₆ x T₁ | 100.67 | 94.00  | 97.34 | 133.00 | 128.67 | 130.84 |
| 17 L₆ x T₂ | 101.67 | 92.00  | 96.84 | 134.67 | 128.00 | 131.34 |
| 18 L₆ x T₃ | 101.33 | 94.67  | 98.00 | 134.00 | 129.67 | 131.84 |
| 19 L₇ x T₁ | 101.00 | 93.67  | 97.34 | 132.33 | 129.00 | 130.67 |
| 20 L₇ x T₂ | 100.00 | 93.67  | 96.84 | 133.00 | 129.33 | 131.17 |
| 21 L₇ x T₃ | 103.00 | 94.00  | 98.50 | 135.00 | 129.00 | 132.00 |
| Mean      | 100.43 | 92.33  | 96.38 | 133.14 | 127.71 | 130.43 |
| LSD 0.05  | 2.01   | 1.95   | 1.67  | 1.42   | 1.61   | 1.48   |
| LSD 0.01  | 2.68   | 2.59   | 2.20  | 1.88   | 2.14   | 1.94   |
Table (4): Means of lines, testers and their F1 crosses for grain filling period and grain filling rate under normal, water stress and their combined data during 2011/2012 season.

| Genotypes  | Grain filling period (day) | Grain filling rate (g/day) |
|------------|----------------------------|---------------------------|
|            | Normal | Stress | Comb. | Normal | Stress | Comb. |
| Line-1     | 35.67  | 37.00  | 36.34 | 0.87   | 0.66   | 0.76  |
| Line-2     | 32.33  | 35.00  | 33.67 | 0.85   | 0.69   | 0.77  |
| Line-3     | 35.67  | 38.33  | 37.00 | 1.05   | 0.60   | 0.82  |
| Line-4     | 32.00  | 34.67  | 33.34 | 1.05   | 0.81   | 0.92  |
| Line-5     | 31.33  | 33.34  | 32.34 | 1.08   | 0.66   | 0.86  |
| Line-6     | 33.00  | 36.00  | 34.50 | 1.17   | 0.82   | 0.99  |
| Line-7     | 29.33  | 30.67  | 30.00 | 1.09   | 0.94   | 1.01  |
| Tester-1 (Giza 129) | 34.00  | 34.34  | 34.17 | 0.72   | 0.57   | 0.65  |
| Tester-2 (Giza 130) | 33.33  | 33.66  | 33.50 | 1.02   | 0.69   | 0.85  |
| Tester-3 (Giza 131) | 30.00  | 34.67  | 32.34 | 1.27   | 0.88   | 1.06  |

The flag leaf area means were decreased affected by water stress (Table 5). Among parents, line 6 and tester 3 under all conditions and top cross 20 under stress and combined and cross 11 under normal were the highest parents and crosses for flag leaf area. On the other hand, the parental line 2, tester 1 under all conditions and top cross 9 under stress and combined and cross 15 under normal were the lowest parents and crosses for flag leaf area.

The total chlorophyll content means were decreased once and increased another in normal than in water stress (Table 5). Rana et al., (2006) reported that the photosynthesis per unit leaf was not initially reduced by stress, as the chlorophyll per unit was higher in stress than non-stress conditions (the leaves were narrower, the cells were smaller and so the chlorophyll density was greater). Among parents, line 2 under normal and combined, line 3 under stress, tester 2
under stress and combined, tester 3 under normal and top cross 5 under stress and combined and cross 7 under normal were the highest parents and crosses for this trait. On the other hand, the parental line 4 under normal, line 5 under stress and combined, tester 1 under all conditions and top cross 13 under normal and combined and cross 11 under stress were the lowest parents and crosses for total chlorophyll content.

Table (5): Means of lines, testers and their F1 crosses flag leaf area and total chlorophyll content under normal, water stress and their combined data during 2011/2012 season.

| Genotypes | Flag leaf area (cm²) | Total chlorophyll content |
|-----------|----------------------|---------------------------|
|           | Normal | Stress | Comb. | Normal | Stress | Comb. |
| Line-1    | 12.42  | 12.00  | 12.21 | 43.40  | 44.00  | 43.70 |
| Line-2    | 8.47   | 7.45   | 7.96  | 48.80  | 42.93  | 45.87 |
| Line-3    | 11.17  | 10.15  | 10.66 | 46.00  | 45.13  | 45.57 |
| Line-4    | 13.17  | 10.34  | 11.76 | 40.50  | 41.63  | 41.07 |
| Line-5    | 13.85  | 11.35  | 12.60 | 41.17  | 40.00  | 40.59 |
| Line-6    | 14.95  | 12.89  | 13.92 | 42.80  | 43.03  | 42.92 |
| Line-7    | 10.69  | 9.72   | 10.21 | 44.50  | 40.70  | 42.60 |
| Tester-1 (Giza 129) | 9.41 | 9.00 | 9.21 | 38.27 | 42.10 | 40.19 |
| Tester-2 (Giza 130) | 9.75 | 9.49 | 9.62 | 41.35 | 48.57 | 44.96 |
| Tester-3 (Giza 131) | 11.82 | 11.53 | 11.68 | 43.27 | 45.70 | 44.49 |
| 1         | L1 x T1 | 16.04 | 11.17 | 13.61 | 42.38 | 47.60 | 44.99 |
| 2         | L1 x T2 | 15.36 | 13.25 | 14.31 | 45.57 | 46.40 | 45.99 |
| 3         | L1 x T3 | 13.11 | 12.32 | 12.72 | 42.73 | 47.17 | 44.95 |
| 4         | L2 x T1 | 13.88 | 11.17 | 12.53 | 41.40 | 47.47 | 44.44 |
| 5         | L2 x T2 | 14.55 | 13.14 | 13.85 | 45.30 | 53.23 | 49.27 |
| 6         | L2 x T3 | 13.55 | 12.60 | 13.08 | 41.50 | 46.87 | 44.19 |
| 7         | L3 x T1 | 16.57 | 13.90 | 15.24 | 48.27 | 44.70 | 46.49 |
| 8         | L3 x T2 | 13.19 | 12.02 | 12.61 | 46.63 | 47.13 | 46.88 |
| 9         | L3 x T3 | 11.36 | 10.36 | 10.86 | 46.70 | 46.73 | 46.72 |
| 10        | L4 x T1 | 14.26 | 12.60 | 13.43 | 44.70 | 46.80 | 45.75 |
| 11        | L4 x T2 | 16.88 | 14.71 | 15.70 | 45.77 | 39.83 | 42.80 |
| 12        | L4 x T3 | 13.28 | 13.00 | 13.14 | 42.83 | 44.43 | 43.63 |
| 13        | L5 x T1 | 12.41 | 11.96 | 12.19 | 27.33 | 43.90 | 35.62 |
| 14        | L5 x T2 | 14.48 | 13.58 | 14.03 | 45.23 | 47.80 | 46.52 |
| 15        | L5 x T3 | 11.25 | 10.98 | 11.12 | 42.87 | 40.97 | 41.92 |
| 16        | L6 x T1 | 13.45 | 12.60 | 13.03 | 42.25 | 47.43 | 44.84 |
| 17        | L6 x T2 | 15.85 | 12.40 | 14.13 | 44.23 | 46.13 | 45.18 |
| 18        | L6 x T3 | 11.58 | 10.58 | 11.08 | 45.07 | 45.80 | 45.44 |
| 19        | L7 x T1 | 12.97 | 12.19 | 11.58 | 42.13 | 50.40 | 46.27 |
| 20        | L7 x T2 | 16.08 | 15.76 | 15.92 | 42.57 | 49.40 | 45.99 |
| 21        | L7 x T3 | 15.08 | 14.96 | 15.02 | 43.27 | 47.57 | 45.42 |
| Mean      | 13.24  | 11.91 | 12.55 | 43.19 | 45.53 | 44.36 |

**Combining ability analysis:**

Analysis of variance for combining ability and estimates of variance due to GCA and SCA are presented in Table (6). General combining ability (GCA) expressed main effects and specific combining ability (SCA) expressed interactions.

|     | LSD  |     | LSD  |
|-----|------|-----|------|
|     | 0.05 | 1.51| 1.18 |
|     | 0.01 | 2.00| 1.55 |
GCA/SCA ratio was used as a measure to understand the nature of gene action involved. The ratios of GCA/SCA were lesser than unity for all studied traits under all conditions, which mean that non-additive gene effects played an important role in the inheritance of these traits. In such cases, a bulk method would be fruitful to eliminate the effect of dominance in the advanced generation. These results agreed with those obtained by Amer (2010), Eid (2010) and Amer et al (2011).

Table (6): Analysis of variance for general (GCA), specific (SCA) combining ability and GCA/SCA under normal, stress and their combined analysis during 2011/2012 season.

| Traits | Days to heading (day) | Days to maturity (day) | Grain filling period (day) | Grain filling rate (g/day) | Total chlorophyll content | Flag leaf area (cm²) |
|--------|-----------------------|------------------------|----------------------------|---------------------------|--------------------------|---------------------|
| \(\sigma^2\)GCA | Normal | 0.04 | 0.04 | 0.017 | 0.007 | 0.34 | 0.02 |
|        | Stress | 0.04 | 0.02 | 0.023 | 0.006 | 0.22 | 0.05 |
|        | Combined | 0.02 | 0.02 | 0.003 | 0.003 | 0.15 | 0.03 |
| \(\sigma^2\)SCA | Normal | 0.85 | 0.69 | 0.812 | 0.029 | 7.22 | 1.88 |
|        | Stress | 2.22 | 0.44 | 0.680 | 0.028 | 4.77 | 0.90 |
|        | Combined | 0.55 | 0.04 | 0.453 | 0.013 | 2.94 | 1.48 |
| Error term | Normal | 0.51 | 0.25 | 0.257 | 0.001 | 6.42 | 0.28 |
|        | Stress | 0.48 | 0.32 | 0.258 | 0.001 | 1.41 | 0.25 |
|        | Combined | 0.37 | 0.29 | 0.195 | 0.003 | 2.63 | 0.18 |
| \(\sigma^2\)GCA/ \(\sigma^2\)SCA | Normal | -0.11 | -0.04 | -0.036 | 0.018 | -0.64 | -0.01 |
|        | Stress | -0.02 | -0.22 | -0.046 | 0.015 | -0.03 | -0.03 |
|        | Combined | -0.16 | 0.09 | -0.052 | 0.004 | -0.66 | -0.01 |

Estimates of general combining ability effects (GCA):

The data of general combining ability effects for all studied traits are presented in Table (7). General combining ability effects varied from one parent to another giving negative or positive values. The significant values of GCA for any genetic variance plays a major role in the positive direction of the desired trait in all the crosses in which the gene type is involved. The negative and significant ones indicated that the flexible portion of genetic variance responses well in the positive direction of desired character in some crosses and negative direction in the other crosses that having the gene type in question as a constant parent. The non-significant GCA indicated that the genotypes have no important effects in the crosses in which they will be involved, but in some cases, they may show important response in specific cross which could be estimated by the SCA.

For **days to heading**, desirable significant negative GCA for days to heading were exhibited from line-1 under water stress and tester-1 under all conditions, indicating that these genotypes could be considered as good combiner for earliness (Table 7-a). Sharma *et al* (2003), Mahmoud, Badeaa (2006) and Mansour (2007) obtained similar results.

With respect to **days to maturity**, all parental lines showed insignificant GCA effects under the two conditions (Table 7-a). For testers, the parental Tester-1 showed desirable significant negative GCA under normal condition and combined, indicating that this genotype could be considered as good combiner for earliness. Mahmoud, Badeaa (2006) and Mansour (2007) found that some parental genotypes gave desirable GCA effects for maturity date.
Table (7-a): Estimates of general combining ability effects for days to heading and days to maturity normal, water stress and their combined data during 2011/2012 season.

| Parents | Days to heading | Days to maturity |
|---------|-----------------|-----------------|
|         | Normal | Stress | Comb. | Normal | Stress | Comb. |
| **Lines** |         |        |        |         |        |        |
| L₁      | -0.19  | -0.94* | -0.56 | -0.03  | -0.27  | -0.15 |
| L₂      | -0.63  | 0.62   | -0.01 | -0.48  | -0.6   | -0.37 |
| L₃      | -0.52  | -0.49  | -0.51 | -0.48  | 0.06   | 0.02  |
| L₄      | 0.48   | 0.51   | 0.49  | 0.30   | 0.4    | 0.24  |
| L₅      | 0.25   | -0.71  | -0.23 | 0.30   | 0.17   | 0.18  |
| L₆      | 0.25   | 0.40   | 0.33  | 0.52   | -0.05  | 0.07  |
| L₇      | 0.37   | 0.62   | 0.49  | -0.14  | 0.29   | 0.02  |
| LSD     | 0.05   | 0.82   | 0.68  | 0.58   | 0.66   | 0.60  |
|         | 0.01   | 1.09   | 1.06  | 0.90   | 0.77   | 0.79  |
| **Testers** |       |        |        |         |        |        |
| T₁ (Giza 129) | -0.92** | -0.59* | -0.75** | -0.79** | -0.21  | -0.69** |
| T₂ (Giza 130) | -0.30  | 0.13   | -0.09 | -0.37  | 0.22   | 0.14  |
| T₃ (Giza 131) | 1.22** | 0.46   | 0.84** | 1.16** | -0.02  | 0.55** |
| LSD     | 0.05   | 0.54   | 0.52  | 0.45   | 0.38   | 0.43  |
|         | 0.01   | 0.72   | 0.69  | 0.59   | 0.5    | 0.52  |

*and **, indicate significant at 0.05 and 0.01 levels of probability, respectively.

**Concerning to grain filling period**, desirable significant negative GCA for grain filling period were obtained from Line-2 under stress and Line-7 under normal condition, indicating that these genotypes could be considered as good combiners for this trait. For testers, desirable values were shown by Tester-3 under water stress (Table 7-b).

**For grain filling rate**, desirable significant positive GCA for grain filling rate were obtain from line-4, line-6 under both conditions and combined, line-3 under normal and line-7 under water stress, indicating that these genotypes could be consider as good combiners for this trait. For testers, desirable values were shown by Tester-3 under both conditions and combined data (Table 7-b).

Desirable significant positive GCA for **flag leaf area** were obtained from Line-4 under both conditions and their combined data and Line-7 under water stress and combined data, indicating that these genotypes could be consider as good combiners for this trait. For testers, desirable values were shown by Tester-2 under stress and combined data (Table 7-c).

Desirable significant positive GCA for **total chlorophyll content** were obtained from Line-3 under normal, Line-2 and Line-7 under water stress, indicating that these genotypes could be considered as good combiners for this trait. For testers, undesirable values were shown by Tester-1 under normal and Tester-3 under water stress where it showed negative GCA values (Table 7-c).
**Table (7-b):** Estimates of general combining ability effects for grain filling period and grain filling rate under normal, water stress and their combined data during 2011/2012 season.

| Parents | Grain filling period | Grain filling rate |
|---------|----------------------|-------------------|
|         | Normal | Stress | Comb. | Normal | Stress | Comb. |
| **Lines** |        |        |      |        |        |       |
| L₁      | 0.16   | 0.67*  | 0.41 | -0.12**| -0.03* | -0.07**|
| L₂      | 0.49   | -1.22**| -0.37| -0.11**| -0.04* | -0.07**|
| L₃      | 0.49   | 0.56   | 0.52*| 0.10**  | -0.16**| -0.03  |
| L₄      | -0.40  | -0.11  | -0.25| 0.06**  | 0.09**  | 0.08** |
| L₅      | -0.06  | 0.89** | 0.41 | 0.03    | -0.15**| -0.06* |
| L₆      | -0.06  | -0.44  | -0.25| 0.14**  | 0.24**  | 0.19** |
| L₇      | -0.62* | -0.33  | -0.48| -0.11** | 0.05**  | -0.03  |
| LSD 0.05| 0.59   | 0.59   | 0.51 | 0.04    | 0.03    | 0.06   |
|         | 0.01   | 0.78   | 0.68 | 0.05    | 0.05    | 0.08   |

**Testers**

|         | Flag leaf area | Total chlorophyll content |
|---------|----------------|---------------------------|
|         | Normal | Stress | Comb. | Normal | Stress | Comb. |
| **Lines** |        |        |      |        |        |       |
| L₁      | 0.02   | -0.51  | 0.19 | 0.29   | 0.50   | 0.39  |
| L₂      | -0.82**| -0.46  | -0.20| -0.54  | 2.63** | 1.04  |
| L₃      | 0.40   | -0.33  | -0.29| 3.93** | -0.37  | 1.78  |
| L₄      | 1.14** | 0.77** | 0.79**| 1.16   | -2.87**| -0.86 |
| L₅      | -0.87**| -0.49  | -0.86**| -4.80**| -2.34**| -3.57**|
| L₆      | 0.04   | -0.57* | -0.44| 0.58   | -0.1   | 0.24  |
| L₇      | 0.08   | 1.59** | 0.82**| -0.62  | 2.56** | 0.97  |
| LSD 0.05| 0.62   | 0.57   | 0.48 | 2.93   | 1.37   | 1.83  |
|         | 0.01   | 0.82   | 0.76 | 0.63   | 3.89   | 1.82  | 2.41  |

**Testers**

|         | Flag leaf area | Total chlorophyll content |
|---------|----------------|---------------------------|
|         | Normal | Stress | Comb. | Normal | Stress | Comb. |
| **Lines** |        |        |      |        |        |       |
| T₁ (Giza 129) | -0.63** | -0.53** | -0.27| -2.06* | 0.34   | -0.86 |
| T₂ (Giza 130) | 0.36   | 0.79** | 1.01**| 1.77   | 0.57   | 1.17  |
| T₃ (Giza 131) | 0.27   | -0.26  | -0.74**| 0.29   | -0.91* | -0.31 |
| LSD 0.05   | 0.4    | 0.38   | 0.32 | 1.92   | 0.9    | 1.20  |
|         | 0.01   | 0.54   | 0.5  | 0.42   | 2.55   | 1.19  | 1.58  |

*and **, indicate significant at 0.05 and 0.01 levels of probability, respectively.
Estimates of specific combining ability effects (SCA):

The estimates of specific combining ability effects of all barley parental combinations were compute for all traits under normal, water stress and their combined as are presented in Table (8a-c).

For days to heading, earliness is favorable in barley for escaping destructive injuries caused by stress conditions. Data in table (8-a) show that crosses no.: 7 under normal, 4, 12, 17 under stress and 12 under combined exhibited significant or highly significant negative SCA values. Based on these results, these crosses are the best for earliness under these conditions. Similar results were obtained by Sharma et al (2003) and Mansour (2007) in their crosses. While, Mahmoud, Badeaa (2006) obtained insignificant SCA effect for this trait in all crosses.

For days to maturity, significant or highly significant negative estimates of SCA effects were detected in the crosses; 6, 13, 18 under normal and cross 12 under water stress (Table 8-a). From these results it could be concluded that these crosses are the best crosses for earliness in maturity under the detected conditions. Similar results were obtained by Mansour (2007). While, Mahmoud, Badeaa (2006) obtained insignificant SCA for this trait in all crosses.

Table (8-a): Estimates of specific combining ability effects for days to heading and days to maturity under normal, water stress and their combined data during 2011/2012 season.

| Crosses | Days to heading | Days to maturity |
|---------|----------------|-----------------|
|         | Normal | Stress | Comb. | Normal | Stress | Comb. |
| Line-1  | Giza 129 (1) | 1.14 | -0.63 | 0.25 | -0.21 | -0.68 | -0.09 |
|         | Giza 130 (2) | -1.14 | -0.02 | -0.58 | 0.03 | 0.56 | 0.08 |
|         | Giza 131 (3) | 0.00 | 0.65 | 0.33 | 0.17 | 0.13 | 0.01 |
| Line-2  | Giza 129 (4) | 0.25 | -1.86** | -0.80 | 0.90 | -0.68 | -0.03 |
|         | Giza 130 (5) | 0.63 | -0.57 | 0.03 | 0.48 | -0.11 | 0.13 |
|         | Giza 131 (6) | -0.89 | 2.43** | 0.77 | -1.38** | 0.79 | -0.10 |
| Line-3  | Giza 129 (7) | -1.86* | -0.08 | -0.97 | 0.24 | -0.02 | -0.09 |
|         | Giza 130 (8) | 0.86 | 0.87 | 0.87 | -0.52 | 0.56 | 0.41 |
|         | Giza 131 (9) | 1.00 | -0.79 | 0.10 | 0.29 | -0.54 | -0.33 |
| Line-4  | Giza 129 (10) | -1.19 | 0.25 | -0.47 | -0.54 | 0.65 | 0.19 |
|         | Giza 130 (11) | 0.86 | 2.54** | 1.70** | -0.63 | 0.89 | 0.52 |
|         | Giza 131 (12) | 0.33 | -2.79** | -1.23* | 1.17* | -1.54** | -0.71 |
| Line-5  | Giza 129 (13) | 0.70 | 0.81 | 0.75 | -1.21* | 0.54 | -0.25 |
|         | Giza 130 (14) | -0.92 | -0.90 | -0.91 | 0.03 | -0.89 | -0.75 |
|         | Giza 131 (15) | 0.22 | 0.10 | 0.16 | 1.17* | 0.35 | 1.01 |
| Line-6  | Giza 129 (16) | 0.37 | 1.03 | 0.70 | 0.57 | 0.10 | 0.19 |
|         | Giza 130 (17) | 0.75 | -1.68* | -0.47 | 0.81 | -1.00 | -0.14 |
|         | Giza 131 (18) | -1.11 | 0.65 | -0.23 | -1.38** | 0.90 | -0.05 |
| Line-7  | Giza 129 (19) | 0.59 | 0.48 | 0.53 | 0.24 | 0.10 | 0.08 |
|         | Giza 130 (20) | -1.03 | -0.24 | -0.63 | -0.19 | 0.00 | -0.25 |
|         | Giza 131 (21) | 0.44 | -0.24 | 0.10 | -0.05 | -0.1 | 0.17 |
| LSD 0.05 | 1.42 | 1.38 | 1.18 | 1.00 | 1.14 | 1.05 |
|         | 0.01 | 1.89 | 1.83 | 1.56 | 1.33 | 1.51 |
|         |         |         |         |         |         |         |
*and **, indicate significant at 0.05 and 0.01 levels of probability, respectively.

For grain filling period, significant or highly significant negative SCA effects were found in the crosses; 6 under stress, 9 under normal, 11 under stress and combined and 13 under normal condition and combined. This showing that these crosses could be considered as the best for this trait (Table 8-b).
For grain filling rate, significant or highly significant positive SCA effects were found in the crosses; 3, 5, 12, 17 under both conditions and their combined, 7 under normal and water stress conditions, 10, 15 under stress and 13 under normal condition and combined. This showing that these crosses could be considered as the best for this trait (Table 8-b).

Table (8-b): Estimates of specific combining ability effects for grain filling period and grain filling rate under normal, water stress and their combined data during 2011/2012 season.

| Crosses   | Grain filling period | Grain filling rate |       |
|-----------|----------------------|--------------------|-------|
|           | Normal   | Stress   | Comp.  | Normal   | Stress   | Comb.  |
| Line-1    |          |          |        |          |          |        |
| Giza 129  (1) | -0.63    | -0.05    | -0.34  | 0.09**   | -0.03    | 0.03   |
| Giza 130  (2) | 0.75     | 0.57     | 0.66   | -0.15**  | -0.10**  | -0.13**|
| Giza 131  (3) | -0.11    | -0.52    | -0.32  | 0.07*    | 0.13**   | 0.10*  |
| Line-2    |          |          |        |          |          |        |
| Giza 129  (4) | 0.37     | 1.17*    | 0.77   | -0.09**  | -0.04    | -0.06  |
| Giza 130  (5) | -0.25    | 0.46     | 0.10   | 0.10**   | 0.14**   | 0.12*  |
| Giza 131  (6) | -0.11    | -1.63**  | -0.87  | -0.01    | -0.11**  | -0.06  |
| Line-3    |          |          |        |          |          |        |
| Giza 129  (7) | 1.70**   | 0.06     | 0.88*  | 0.07*    | 0.12**   | 0.09   |
| Giza 130  (8) | -0.59    | -0.32    | -0.45  | 0.04     | -0.01    | 0.02   |
| Giza 131  (9) | -1.11*   | 0.25     | -0.43  | -0.11**  | -0.11**  | -0.11* |
| Line-4    |          |          |        |          |          |        |
| Giza 129  (10) | 0.92     | 0.40     | 0.66   | -0.28**  | 0.08**   | -0.10* |
| Giza 130  (11) | -0.70    | -1.65**  | -1.17**| 0.18**   | -0.28**  | -0.05  |
| Giza 131  (12) | -0.22    | 1.25*    | 0.52   | 0.10**   | 0.20**   | 0.15** |
| Line-5    |          |          |        |          |          |        |
| Giza 129  (13) | -1.75**  | -0.27    | -1.01* | 0.29**   | -0.04    | 0.13** |
| Giza 130  (14) | 0.30     | 0.02     | 0.16   | -0.19**  | -0.05    | -0.12* |
| Giza 131  (15) | 1.44**   | 0.25     | 0.85   | -0.11**  | 0.09**   | -0.01  |
| Line-6    |          |          |        |          |          |        |
| Giza 129  (16) | -0.08    | -0.94    | -0.51  | -0.12**  | -0.10**  | -0.11* |
| Giza 130  (17) | -0.03    | 0.68     | 0.33   | 0.10**   | 0.27**   | 0.19** |
| Giza 131  (18) | 0.11     | 0.25     | 0.18   | 0.02     | -0.17**  | -0.08  |
| Line-7    |          |          |        |          |          |        |
| Giza 129  (19) | -0.52    | -0.38    | -0.45  | 0.04     | 0.01     | 0.03   |
| Giza 130  (20) | 0.52     | 0.24     | 0.38   | -0.07*   | 0.02     | -0.03  |
| Giza 131  (21) | 0.00     | 0.14     | 0.07   | 0.03     | -0.04    | 0.00   |
| LSD 0.05  | 1.01     | 1.02     | 0.88   | 0.07     | 0.06     | 0.10   |
| 0.01      | 1.35     | 1.35     | 1.17   | 0.09     | 0.08     | 0.13   |

*and **, indicate significant at 0.05 and 0.01 levels of probability, respectively.

With respect to flag leaf area, barley crosses; 7 at the two conditions and their combined, 1 under normal and 21 under water stress and combined, are considered to be promising barley hybrids for improving this trait, where they showed significant or highly significant positive SCA effects (Table 8-c).

Regarding to total chlorophyll content, significant or highly significant positive SCA effects were found in the crosses; 5, 10 under stress and 14 under water stress condition and combined. This showing that these crosses could be considered as the best for this trait (Table 8-c).
Table (8-c): Estimates of specific combining ability effects for flag leaf area and total chlorophyll content under normal, water stress and their combined data during 2011/2012 season.

| Crosses | Flag leaf area | Total chlorophyll content |
|---------|----------------|----------------------------|
|         | Normal | Stress | Comb. | Normal | Stress | Comb. |
| Line-1  |         |        |       |        |        |       |
| Giza 129 (1) | 1.84** | -0.54 | 0.33  | 0.89   | 0.20   | 0.55  |
| Giza 130 (2) | 0.16   | 0.21   | -0.24 | 0.24   | -1.23  | -0.50 |
| Giza 131 (3) | -2.00** | 0.33  | -0.09 | -1.12  | 1.02   | -0.05 |
| Line-2  |         |        |       |        |        |       |
| Giza 129 (4) | 0.51   | -0.60  | -0.36 | 0.73   | -2.06  | -0.67 |
| Giza 130 (5) | 0.20   | 0.04   | -0.31 | 0.80   | 3.47** | 2.13  |
| Giza 131 (6) | -0.71  | 0.56   | 0.67  | -1.53  | -1.41  | -1.47 |
| Line-3  |         |        |       |        |        |       |
| Giza 129 (7) | 1.99** | 2.00** | 2.43**| 3.13   | -1.83  | 0.65  |
| Giza 130 (8) | -2.39** | -1.20*| -1.47**| -2.34  | 0.37   | -0.98 |
| Giza 131 (9) | 0.40   | -0.80  | -0.96*| -0.79  | 1.46   | 0.33  |
| Line-4  |         |        |       |        |        |       |
| Giza 130 (10) | -1.05  | -0.40  | -0.44 | 2.33   | 2.77** | 2.55  |
| Line-5  |         |        |       |        |        |       |
| Giza 129 (11) | 0.38   | 0.38   | 0.55  | -0.44  | -4.43**| -2.43 |
| Giza 131 (12) | 0.67   | 0.01   | -0.11 | -1.89  | 1.66   | -0.12 |
| Giza 129 (13) | -0.9   | 0.23   | -0.04 | -9.08**| -0.66  | -4.87**|
| Giza 130 (14) | 0.18   | 0.53   | 0.54  | 4.99   | 3.00*  | 4.00* |
| Giza 131 (15) | 0.71   | -0.75  | -0.50 | 4.10   | -2.34  | 0.88  |
| Line-6  |         |        |       |        |        |       |
| Giza 129 (16) | -0.77  | 0.94   | 0.38  | 0.46   | 0.64   | 0.55  |
| Giza 130 (17) | 0.64   | -0.59  | 0.21  | -1.39  | -0.9   | -1.14 |
| Giza 131 (18) | 0.13   | -0.35  | -0.59 | 0.92   | 0.26   | 0.59  |
| Line-7  |         |        |       |        |        |       |
| Giza 129 (19) | -1.63**| -1.62**| -2.33**| 1.54   | 0.94   | 1.24  |
| Giza 130 (20) | 0.83   | 0.62   | 0.74  | -1.86  | -0.30  | -1.08 |
| Giza 131 (21) | 0.80   | 1.00*  | 1.59**| 0.32   | -0.64  | -0.16 |
| LSD 0.05 | 1.07   | 0.99   | 0.84  | 5.07   | 2.37   | 3.18  |
| 0.01    | 1.42   | 1.32   | 1.10  | 6.74   | 3.16   | 4.17  |

*and ** indicate significant at 0.05 and 0.01 levels of probability, respectively.

Coefficients of variability:

Phenotypic and genotypic coefficients of variability for all the studied traits are presented in Table (9). Genotypic coefficients of variability measures the variability of any trait. Moreover, the genotypic coefficients of variability together with the heritability estimates would seem to give the best picture of the amount of genetic advance to be expected from selection. The extent of the environmental influence on any trait indicated by the magnitude of the differences between the phenotypic and genotypic coefficients of variability. Large differences reflect high environmental influence, while small differences reveal high genetic influence.

Results indicated that, phenotypic coefficients of variability were slightly higher than the genotypic coefficients of variability for all studied traits under both conditions. This indicates the presence of environmental influence to some degree in the phenotypic expression of the studied traits. Low phenotypic and genotypic coefficients of variability were obtained for days to heading, days to maturity and grain filling period under all conditions. These results may be due to the presence of both positive and negative alleles in the population.
Small differences between genotypic and phenotypic coefficients of variability were found for all studied traits under all conditions, indicating the presence of sufficient genetic variability for these traits, which may facilitate selection.

### Heritability and expected genetic advance from selection:

Heritability estimates in both broad and narrow senses and expected genetic advance from selection for all the studied traits are presented in Table (10). To achieve genetic improvement through selection, heritability must be reasonably high (Calhoun et al. 1994).

Broad sense heritability percentages ranged from moderate to high with percentages ranged from 10.82% for days to maturity at combined data to 97.30% for grain filling rate under normal condition. These results indicate that genotypic variances played the major part of phenotypic variances.

Narrow sense heritability percentages varied from low to moderate with percentages ranged from 0.92 % for grain filling period at combined data to 18.92% for grain filling rate under normal condition. These results agreed with those obtained by El-Bawab (2003) and Eid (2006), where they recorded high values of broad sense heritability. While, high to moderate values in narrow sense were recorded by El-Bawab (2003) for days to heading. On the other hand, Eid (2006) and El-Akhdar (2011) recorded high values of narrow sense heritability for this trait.

The expected genetic advance (Δg) ranged from 0.02 for grain filling period at combined data to 0.36 for total chlorophyll content under normal condition. While, the estimates of predicted genetic advance (Δg %) ranged from 0.04% for grain filling period at combined data to 7.41% for grain filling rate under stress condition. These results agreed with those obtained by El-Seidy (1997a) who found the expected gain from selection ranged from 2.77 to 4.22%, and Martinez and Foster (1998) found low genetic advance estimates. While, Sinha and Saha (1999) found moderate genetic advance for days to heading.

Generally, traits that showed high values of narrow sense heritability and expected genetic advance from selection should be used in breeding program where selection in the early segregating generations will be useful because additive gene action is more important than non-additive genetic components.
Table (11): Heritability estimates in broad and narrow senses and expected genetic advance from selection for all the studied traits under normal, water stress and their combined data during 2011/2012 season.

| Parameter                      | Characters | Parameter | Normal | Stress | Comb. | Parameter | Normal | Stress | Comb. | Parameter | Normal | Stress | Comb. |
|--------------------------------|------------|-----------|--------|--------|-------|-----------|--------|--------|-------|-----------|--------|--------|-------|
|                                | Days to heading | $h^2_{(b.s)}$ | 64.52  | 5.15   | 0.13  | $h^2_{(n.s)}$ | 82.82  | 2.46   | 0.08  | $\Delta g$ | 0.13   | 0.08   | 0.08  |
|                                |            | $\Delta g$%  |        |        |       |            |        |        |       |            |        |        |       |
|                                | Days to maturity | Normal | 75.39  | 7.26   | 0.15  | Stress     | 59.22  | 3.91   | 0.07  | Comb.     | 10.82  | 4.86   | 0.08  |
|                                |            | $\Delta g$%  |        |        |       |            |        |        |       |            |        |        |       |
|                                | Grain filling period | Normal | 76.70  | 3.08   | 0.07  | Stress     | 73.78  | 4.67   | 0.10  | Comb.     | 7.02   | 0.92   | 0.02  |
|                                |            | $\Delta g$%  |        |        |       |            |        |        |       |            |        |        |       |
|                                | Grain filling rate | Normal | 97.30  | 18.92  | 0.07  | Stress     | 97.14  | 17.14  | 0.07  | Comb.     | 86.49  | 16.22  | 0.05  |
|                                |            | $\Delta g$%  |        |        |       |            |        |        |       |            |        |        |       |
|                                | Total chlorophyll content | Normal | 55.1   | 4.65   | 0.36  | Stress     | 78.69  | 6.51   | 0.34  | Comb.     | 38.06  | 3.36   | 0.20  |
|                                |            | $\Delta g$%  |        |        |       |            |        |        |       |            |        |        |       |
|                                | Flag leaf area | Normal | 87.1   | 1.41   | 0.04  | Stress     | 80.08  | 7.34   | 0.17  | Comb.     | 80.75  | 2.49   | 0.07  |
|                                |            | $\Delta g$%  |        |        |       |            |        |        |       |            |        |        |       |

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