Jordan Journal of Agricultural Sciences, Volume **4**, No.**4**, 2008

Genetic Variation, Heritability and Interrelationships of Agro-Morphological and Phenological Traits in Jordanian DURUM Wheat Landraces

Adel H. Abdel-Ghani*

ABSTRACT

Nine hundred and twenty lines of durum wheat landraces collected from ten locations in Jordan and seven checks (Haurani 27, Acsad 65, Om Qais, Sham 3, Sham1, Sham 5 and Deiralla 6) were evaluated under field conditions in two contrasting environments (semi-arid and arid conditions) on the basis of single head row progeny. The objectives were to estimate phenotypic (PCV) and genetic (GCV) coefficients of variation, broad sense heritability (h^2)and genetic advance (GA) using the variance components method based on the combined analyses over locations and the variance analyses for each location for various agro-morphological and phenological traitsand to determine the interrelationships among these traits. Because of high genotype × location (G × L) interactions, estimates of GCV, h^2 and GA for different traits using combined analysis were generally lower than the estimates computed from the variance analyses made separately for each location. The high cross-over G × L interactions could affect selection efficiency since lines selected under optimum growing conditions do not always perform well under poor conditionsand vice versa, recommending to have perform selection for each target environment. Intermediate to high estimates of PCV, GCV, h^2 and GA (as % of the mean) were observed for grain yield plant^{-1} (GYP), biological yield plant^{-1}, straw yield plant^{-1}, number of spikes plant^{-1} (NSP), number of kernels spike^{-1} (NKS), hundred kernel weight (HKW) and average spike weight (ASW). NSP, NKS, HKW and ASW were positively correlated with GYP, indicating possibility for improvement of wheat landraces by indirect selection for NSP, NKS, HKW and ASW. Moreover, grain yield exhibited weak negative correlation with days to heading, days to maturity and grain filling period, showing the importance of earliness under drought stress conditions. Several lines differed statistically from the checks, indicating the possibility of their use in a breeding program to improve different agro-morphological traits. In conclusion, this study indicates that the improvement of the Jordanian wheat landraces may be possible either through indirect selection for yield components or direct selection for grain yield *per se*.

Keywords: Landraces, Pure Lines, Durum Wheat, Breeding.

INTRODUCTION

Durum wheat (*Triticum turgidum* L. subsp. *durum* conv. *durum* (Desf.) Mackey) landraces are still the major source of seed for planting in most of the traditional durum wheat growing areas in Jordan. Landraces are often heterogeneous and composed of different genotypes which are mostly homozygous and usually exhibit considerable genetic variation for quantitative and qualitative traits (Harlan, 1975; Frankel et al., 1995; Jaradat et al., 2004), and at the DNA level (Shoaib and Arabi, 2006; Yifru et al., 2006; Duwayri et al., 2007). The lines forming landraces generally vary in

---

* Mutah University, Faculty of Agriculture, Department of Plant Production, P.O. Box 7, Al-Karak-Jordan. Tel.: 00962-799771229, Fax: 00962-3-2323154. abdelghani@mutah.edu.jo or abdghani55445@yahoo.com
Received on 27/4/2008 and Accepted for Publication on 21/7/2008.

© 2008 DAR Publishers/University of Jordan. All Rights Reserved.

their yield capacity, disease reaction, maturity, seed colour and other traits which allow their survival and their adaptation to harsh conditions and low input cultivation (Weltzien, 1988; Weltzien and Fischbeck, 1990; Jaradat et al., 2004). In spite of that, the landraces are replaced by improved varieties which leads to a drastic reduction in genetic diversity (Damania, 1989).

Successful breeding programs mainly depend on the availability of genetic variation (Hawkes, 1977). However, utilization of genetic resources as a source of variability requires their proper systematic evaluation (Belay et al., 1993). Two different approaches have been used to study the magnitude of genetic variation in wheat landraces. One is to collect the landraces from different eco-geographical regions and measure the magnitude of variation between the landraces (Negassa, 1985; Kebebew et al., 2001; Eticha et al., 2006), the other is to assess the variability of different traits among the pure lines (i. e., individual spikes) extracted from landraces (Ceccarelli and Grando, 2000; Baydar et al., 1999). Previous studies have revealed considerable variation in wheat landraces from Ethiopia (Tesfaye et al., 1991; Kebebew et al., 2001; Eticha et al., 2006), Iran (Ehdaie and Waines, 1989) and Jordan (Jaradat, 1991; Abdel-Ghani et al., 2001). Previous research has studied variability in the Jordanian wheat landraces for morphological and agronomic traits, mainly by quantifying the variation within and between geographic regions (Jaradat, 1991; Abdel-Ghani et al., 2001). The significance of these studies in terms of collections strategies and breeding purposes will gain more by partitioning of the observed variability into its heritable and non-heritable components and by estimating the expected genetic advance for agronomic traits. Therefore, the current study aimed at quantifying the phenotypic and genetic coefficients of variation, heritability (broad sense), expected genetic advance and correlation coefficients between various agro-morphological and phenological traits under near optimum (i.e., semi-arid) and water stressed (arid) environments.

MATERIALS AND METHODS

A total of 920 durum wheat lines were used in this study. These lines were collected from 10 sampling sites in Jordan in June 2005 (Table 1). Collection of landraces and selection of spikes within landraces were made at random without a priori bias for any of characters. Hence, they are considered representative of the germplasm at the collection sites. The set of check varieties (Haurani 27, Acsad 65, Om Qais, Sham 3, Sham1, Sham 5 and Deiralla 6) obtained from the National Center for Agricultural Research and Extension, Jordan, were also included in the evaluation.

The field experiments were carried out at Mu'tah University Agricultural Station (MUAS) at Rabba (semi-arid, 31° 16' N, 35° 45' E and ca 920 meters above sea level) and Ghweer Agricultural Station (GAS) (arid, 31° 14' N, 35° 45' E and ca 820 meters above sea level) in Jordan during 2005/2006 growing season. The two test locations represent two contrasting environments. The former has a relatively moderate rainfall (310 mm long-term annual average), suitable to cultivate a wide range of crops especially wheat and legumes and the latter is drier (240 mm long-tem annual average).

The lines and check varieties were grown in two replicated randomized complete blocks and in 1-m rows (i.e., 5 seeds row^{-1}) with 0.25 m intra-block and 2 m inter-block distances. All pre- and post-stand establishment management such as land preparation, cultivation and weeding was done as required. Data were collected for the following nine different agro-morphological and phenological traits: plant height at maturity (cm; from soil surface to tip of spike excluding awns), grain yield (g plant^{-1}), biological yield (g plant^{-1}), straw yield (g plant^{-1}), number of spikes plant^{-1}, hundred kernel weight (g), average spike weight (g), days to heading from emergence (50% of spikes fully emerged from flag leave), days to maturity from emergence (50% of peduncles turned yellow). Moreover, three additional traits were also derived from the previous data: number of kernels spike^{-1}, grain filling period (days) and harvest index. Data on days to heading and maturity, grain filling period and plant height were recorded on plot basis, whereas other traits were computed from the three central individual plants within each plot (i.e., row), excluding one plant from the both sides to avoid border effects.

Statistical Analysis

Estimates of broad sense heritability (h^2) for different traits were computed using the variance components method based on the combined analyses over the two test locations and based on the results of the variance analyses made separately for each environment using one way analysis of variance as follows:

a) Estimation of h^2 Using Combined Analyses Across the Two Test Environments

Initially the data were subjected to randomized complete block design (RCBD) analyses of variance. The homogeneity of variances for the two locations was checked by use of Leven's test. Appropriate transformations (logarithmic, square root) were performed when necessary. Tests for outlayers were conducted according to Anscombe and Tukey (1963) and significant outlayers were considered as missing values in the analyses. Entry means were used in the combined analyses across environments. Variance components were estimated according to Snedecor and Cochran (1980) as follows:

$$V_g = (MS_g - MS_{gl})/rl\,,$$

$$V_{gl} = (MS_{gl} - MS_e)/r\,,$$

$$V_e = MS_e \text{ and}$$

$$V_{ph} = V_g + V_{gl}/r + V_e/rl$$

where V_g, V_{gl}, V_e and V_{ph} are the variances due to genotypes (lines), genotype × location (G × L) interaction, experimental error and phenotypes, respectively. MS_g, MS_{gl} and MS_e are the mean squares of genotypes (i.e., lines), genotype× location (G × L) interaction and pooled error, and l denotes the number of environments (i.e., locations) and r the number of replications.

The effects of locations were regarded as fixed, and all other effects were assumed to be random variables. Broad sense heritability (h^2) estimates are based on entry means and are computed as the ratio of the genotypic variance (V_g) to the phenotypic variance (V_{ph}).

b) Estimation of h^2 using single environment analysis of variance: Estimates of h^2 for different traits were also computed based on the results of one-way analysis of variance made separately for each environment. Variance components (genotypic, phenotypic and error variance) were estimated using the formula of Wricke and Weber (1986) as follows:

$$V_g = (MS_g - MS_e)/r$$

$$V_e = MS_e$$

$$V_{ph} = V_g + V_e$$

where V_g, V_e and V_{ph} are the variances due to genotypes (lines), error and phenotypes, respectively. MS_g, MS_e and r are the mean squares of genotypes, mean squares of experimental error and number of replications, respectively. Broad sense heritability (h^2) is expressed as the percentage of the ratio of the genotypic variance (V_g) to the phenotypic variance (V_{ph}) as described by Allard (1999).

In accordance to the methods used by Johnson et al. (1955) and Kumar et al. (1985), the phenotypic (PCV) and genotypic variance (GCV) coefficients of variation were estimated as a percentage of their corresponding phenotypic ($\sqrt{V_{ph}}$) and genotypic $\sqrt{V_g}$ standard deviations to the trait grand mean. Expected genetic advance (GA) and GA as percent of the mean assuming selection of the superior 5% of the genotypes were estimated in accordance with the methods illustrated by Fehr (1987):

$$GA = K(\sqrt{V_{ph}})h^2$$

$$GA \text{ (as \% of the mean)} = \left(GA/\overline{X}\right)100\%$$

where *K* is a constant which at a selection intensity of 5% is about 2.06, $\left(\sqrt{V_{ph}}\right)$ is the phenotypic standard deviation, h^2 is the heritability ratio and $\overline{X}$ refers to the mean of the character.

Correlation coefficients were calculated to assess the interrelationship among different plant characters in each location. In order to identify superior lines which exceeded the value of the best standard check, the differences between the means were compared using Least Significant Difference (LSD) at $P \leq 0.05$. All statistical computations were performed with the computer program PLABSTAT (Utz, 2000).

RESULTS

Weather Data

Precipitation in the 2005/2006 growing season was higher at MUAS than at GAS and close to the long-term annual average at MUAS but was 20 mm less than the average at GAS (Fig. 1). Effective rains sufficient for germination started in mid- February 2006 at GAS with a high intensity (about 43% of the total rainfall) and on 23 December 2005 at MUAS. Although more rainfall was received at MUAS compared to GAS, poor rainfall was recorded at the beginning of the growing season at MUAS (from the middle of December 2005 to the middle of February 2006); whereas abundant rains were received at both locations from the middle of February to the middle of April 2006. No rains were received at both locations after the mid- April, coupled with high temperature (Figure 1). Significant reduction ($P<0.01$), under the stress conditions of GAS, was observed in plant height, grain yield plant^{-1}, biological yield plant^{-1}, straw yield plant^{-1}, number of kernels spike^{-1}, hundred kernel weight, average spike weight and pheonological traits, while harvest index and number of spikes plant^{-1} were not significantly affected.

Genetic Variation

For each of the traits evaluated, the descriptive statistics including the extreme genotype mean values along with the corresponding lines, and the means with their standard deviations obtained on the basis of the averages of data at each of the two test locations are summarized in Table 2. The analysis of variance showed significant differences between lines for all traits recorded.

Estimates of PCV and GCV coefficients of variation, h^2 and GA expected from selecting the superior 5% of lines for each trait computed using the variance components based on the combined analyses over the two test locations are shown in Table 3. Across the traits studied, the PCV ranged from 1.81% for days to maturity to 41.50% for straw yield plant^{-1}. In addition, the PCV values were also relatively high (>30%) for grain yield plant^{-1}, biological yield plant^{-1} and number of spikes plant^{-1}. In contrast, plant height, hundred kernel weight, days to heading, days to maturity and grain filling period showed comparatively low values (<11%). But intermediate PCV estimates (16- 30%) were noted for harvest index, number of kernels spike^{-1}, and average spike weight. The GCV values were the lowest (<2%) for days to maturity and highest (18.88%) for straw yield plant^{-1}. Grain yield plant^{-1} and biological yield plant^{-1} as well as number of spikes plant^{-1}, also showed relatively high GCV values (15-18%). The remaining seven traits (i.e., plant height, harvest index, number of kernels spike^{-1}, hundred kernels weight, average spike weight, days to heading and grain filling period) exhibited GCV values lower than 6%.

The mean squares from the combined variance analysis over the two locations showed significant genetic variation in ten out of twelve traits (Table 3). Locations and lines interacted significantly ($P<0.05$) for the grain filling period, and highly significantly ($P<0.01$) for plant height, grain plant^{-1}, biological plant^{-1}, straw yield plant^{-1}, number of the spikes plant^{-1}, number of kernels per plant, days to heading and maturity and grain filling period. Across traits, plant height and days to heading and maturity showed relatively high h^2 values (>39%). In contrast, h^2 estimates were comparatively low (between 13.49 and 27.27%) for grain yield plant^{-1}, biological yield plant^{-1}, straw yield plant^{-1}, harvest index, number of spikes plant^{-1} and hundred kernel weight. Estimates of GA (as % of the mean) ranged from less than 2% for days to maturity to 19.23% for number of spikes plant^{-1}. Generally, plant height, harvest index, number of kernels spike^{-1}, hundred kernel weight, average spike weight, days to heading, days to maturity and grain filling period showed GA values lower than 10%. As opposed to these, grain yield, biological yield plant^{-1}, straw yield plant^{-1} and number of spikes plant^{-1} showed GA expectations between 12-19%.

In the current study, the magnitude of PCV, GCV, h^2 and GA showed upward estimates when they were computed based on the results of the variance analyses made separately for each of the two test locations (Table 4). Moreover, PCV, GCV, h^2 and GA were affected by yield level of the environment. Of all the 12 traits studied, grain yield plant^{-1}, biological yield plant^{-1}, straw yield plant^{-1} and number of spikes plant^{-1} showed relatively higher PCV, GCV, h^2 and GA% at MUAS than at GAS, while other parameters showed higher PCV, GCV, h^2 and GA at GAS than at MUAS. Considering PCV, GCV, h^2 and GA% simultaneously as the best estimators of the amount of advance expected, grain yield plant^{-1}, biological yield plant^{-1}, harvest index, yield components and average spike weight gave the highest values at both locations. In contrast, plant height, days to heading, days to maturity and grain filling period showed comparatively low PCV, GCV and GA% values but intermediate h^2 estimates.

Correlation between Traits under Near Optimum Versus Water Stressed Environments

Phenotypic correlation coefficients among the traits at MUAS and GAS are presented in Table 5. The correlations amongst plant height, grain yield plant^{-1}, biological yield plant^{-1} and straw yield plant^{-1} were always significant and positive regardless of the location. Harvest index at both locations was positively associated with grain yield plant^{-1}, but showed a negative correlation with straw yield plant^{-1}. Harvest index also exhibited a very weak negative association with plant height and biological yield plant^{-1} at MUAS. Grain yield plant^{-1} was positively associated with number of spikes plant^{-1} (r =0.76** and 0.59** at MUAS and GAS, respectively), number of kernels spike^{-1} (r =0.22** and 0.50** at MUAS and GAS, respectively), hundred kernel weight (r =0.30** and 0.28** at MUAS and GAS, respectively) and average spike weight (r =0.36** and 0.20** at MUAS and GAS, respectively).

The correlations between days to heading, days to maturity and grain filling were always significant and positive at the two experimental locations. The correlations among number of spikes plant^{-1}, hundred kernel weight, number of kernels spike^{-1} and average spike weight were always very weak and non-significant ($r \leq 010$) regardless of the location. At GAS, grain yield plant^{-1}, biological yield $^{-1}$, straw yield $^{-1}$ and harvest index were negatively associated with days to heading (r = -0.17**, -0.17**, -0.09** and -0.21**, respectively) and positively correlated with grain filling period (r =0.20**, 0.25**, 0.16** and 0.17**, respectively). Moreover, days to maturity at GAS was positively correlated with grain yield plant^{-1} and straw yield plant^{-1} (r =0.37**, 0.07**, respectively). At MUAS, grain yield plant^{-1}, biological yield plant^{-1} and straw yield plant^{-1} exhibited weak significant negative associations with days to maturity and grain filling period, but no association with days to heading.

Genotypic Performance

Number and frequency of lines (%) which exceeded the best standard check under near optimum (MUAS) and water stress (GAS) environments are presented in Table 6. About 2.50% and 1.00% of the tested lines significantly exceeded the tallest check cultivar Haurani 27 at MUAS and GAS, respectively. From a total of 920 wheat landrace lines, the number of lines which significantly out-yielded the best standard check for grain yield plant^{-1}, biological yield plant^{-1} and straw yield plant^{-1} were about 54 (5.87%) and 53 (5.76%), about 24 (2.61%) and 40 (4.35%) and about 19 (2.07%) and 32 (3.47%) at MUAS and GAS, respectively. The number of lines exceeding the values of the standard checks for number of spikes plant^{-1} and number of kernels spike^{-1} were about 49 (5.33%) and 33 (3.59%) and about 14 (1.52%) and 25 (2.72%) at MUAS and GAS, respectively. Twenty five lines (2.71%) at MUAS and 5 lines (0.54%) at GAS with larger hundred kernel weight than the best check were identified. Among the total collection, nine lines (1.00%) at MUAS and 5 lines (0.54%) at GAS were significantly earlier in heading than the earliest standard check.

DISCUSSION

The existence in the durum wheat lines of large variability for each of 12 traits assessed offers ample chances for the genetic improvement of the crop through selection and recombination of lines with desired expression. Similar diversity among lines of landraces was reported by Ehaide and Wains (1987), Getachew et al. (1993) and Jaradat et al. (2005).

Most recorded traits were significantly reduced under water stress environment due mainly to drought. Moreover, because of early effective rainfall and relatively more adequate rains received at MUAS, days to heading, days to maturity and grain filling period were elongated, while insufficient early rains received at GAS delayed emergence and substantially shortened these traits. Our results confirmed earlier findings of Ehdaie et al. (1988) and are consistent with those of Jaradat (1992) and Abdel-Ghani et al. (2005).

Because of high G × L interactions, estimates of GCV, h^2 and GA using combined analysis of variance for the different traits were generally lower than the values computed based on the results of the variance analyses made separately for each of the two test locations. Similarly, the estimates for these parameters based on combined analyses across environments in the present study were generally lower than values formerly reported from mono-environment evaluation of wheat from Iran (Ehdaie and Waines, 1989) and Ethiopia (Getachew et al., 1993). Cross-over G × E interaction can be found in the literature in the range of the crops and environments and for various stresses, by Woodend and Glass (1993) in wheat, Ceccarelli (1989) in barley, Ouk et al. (2006) in rice, Haussmann et al. (2000) in sorghum and Virk and Magat (1991) in pearl millet.

The high cross-over G × L interactions detected in the current study could limit selection efficiency, since lines selected under near optimum growing conditions do not always perform well under poor conditions, and *vice versa* (i.e., high performance under favorable conditions is not a useful criterion to identify superior genotypes for dry areas). Therefore, the most effective way to improve the productivity of wheat is to perform selection under targeted environments. Ceccarelli (1994) reported that high grain yield in high-yielding conditions and high grain yield in low yielding conditions are under the control of different sets of alleles at most of the several loci that presumably controlled the grain yield. In contrast to our results, other studies have concluded that selection under favorable conditions could produce lines suitable in both stress and non-stress environments (Arboleda-Rivera and Compton, 1974; Ceccarelli, 1987; Ceccarelli, 1989; Virk and Mangant, 1991). However, others concluded that yield improvement under high stress conditions requires selection strictly under those conditions (Frey, 1964; Roy and Murty, 1970; Laing and Fisher, 1979; Chapman et al., 2000; Haussmann et al., 2000; Ouk et al., 2006)

Grain yield plant^{-1}, biological yield plant^{-1}, straw yield plant^{-1} and number of spikes plant^{-1} showed relatively higher h^2 at near optimum than water stress environment. Our results support the findings of Ceccarelli (1996) in barley and Atlin and Frey (1990) in oat (*Avena sativa* L.) who reported that heritability is higher in high-yielding than in low yielding environments. According to Ceccarelli (1994), the most common justification for conducting selection in optimum environments, regardless of the nature of the target environment, is the lower heritability found in low yielding ones.

Generally, large h^2 values showed relative ease with which selection can be made based on phenotype, but their practical utility in plant breeding is further enhanced if accompanied by concomitantly high GA estimates (Johnson et al., 1955). To this effect, grain yield plant^{-1} and yield components appeared to combine relatively higher values of h^2 and GA estimates at both environments. Thus, the selection of superior lines based on grain yield *per s*e and/or indirect selection for yield components for improving the grain yield would be effective. Yield components showed a positive correlation with grain yield plant^{-1} and displayed relatively the high combinations of GCV, h^2 and GA. Moreover, the correlations amongst yield components were always very weak (≤0.10) or non-significant regardless of the location. The positive correlation of yield components with grain yield plant^{-1} is in agreement with Sidwell et al. (1976) and Bahatt (1973). The wide range of variability in phenology combined with high h^2 estimate implies that it is possible to develop wheat varieties for drought prone areas of Jordan. Thus early varieties can be developed to ensure that pollination and grain filling occur before heat and drought stress become too severe. Likewise, the ranges noted in all other traits offer ample opportunities for improvement through breeding.

Wheat landraces are typically mixtures of a high number of homozygote genotypes. Therefore, landraces contain a large amount of genetic variation within adapted genetic background. In the case of self-pollinated crops such as wheat, pure line selection within heterogeneous populations is one of the easiest, oldest and cheapest methods of plant breeding. The evaluation of a small random sample of a collection of 920 lines revealed that a total of 54 (5.87%) and 53 (5.76%) out yielded the best check at MUAS and GAS, respectively. Also for other traits (plant height, biological yield plant^{-1}, straw yield plant^{-1} and yield components), a considerable number of lines can be used for breeding purposes. Three steps strategy could be followed to utilize the information obtained in this study. This strategy is similar to that used by ICARDA for the improvement of adapted barley landrace materials (Ceccarelli and Grando, 2000): (i) isolate high-yielding pure lines from landraces, and test their stability across a wide range of environments; (ii) utilise foregoing lines as parents in a crossing program to incorporate additional desirable characters; (iii) develop mixtures or multi-line varieties, composed of a variable number of improved pure lines properly characterized for a set of agronomic characters. The latter procedure permits to exploit the buffering capacity of genetically heterogeneous populations to enhance phenotypic stability and will conserve a certain amount of evolutionary process within populations. The existence of high level heterogeneity within landrace populations led to identification of high yielding genotypes from heterogeneous landrace populations locally grown by farmers in several self pollinated crops including wheat (Tesemma et al., 1993), barley (Weltzien, 1988; Jaradat et al., 2004) and sesame (Bayder et al., 1999).

In conclusion, the wide genotypic variation in morphological, agronomic and phenological traits observed in the current study suggests that selection for these traits should be effective in wheat landraces. However, possible cross-over G × L interactions could complicate the selection procedure since lines selected under optimum growing conditions do not perform well under poor conditions, and *vice versa*. Therefore, the most effective way to improve the productivity of wheat landraces is to perform selection under target environment. Moreover, further research is needed to confirm the superiority of selected outstanding lines by evaluation over additional sites and years using larger plot sizes.

ACKNOWLEDGMENT

The author would like to thank the Deanship of Academic Research at Mu'tah University for supporting this research.

Table (1): Eco-geographical information about 10 sampling sites of 920 wheat landrace lines.

Region	District	Site	Latitude (North)	Longitude (East)	Abbr.	Altitude (m)	Long-term average seasonal rainfall (mm) (Oct.-May)
Northern	Irbid	Sal	32˚ 39'	35˚ 49'	IS	490	478
	Ajloun	Samta	32˚ 24'	35˚ 49'	AS	1034	547
Central	Maddaba	Team	31˚ 44'	35˚ 45'	MT	785	358
	Dieban	Baraza	31˚ 34'	35˚ 43'	DB	715	270
	Karak1	Al-Qaser	31° 16'	35˚ 24'	KQ	900	326
	Karak2	Rakeen	31˚ 20'	35˚ 24'	KR	900	326
	Karak3	Mutah	31˚ 03'	35˚ 24'	KM	1200	350
Southern	Tafila	Qadisya	30˚ 47'	35˚ 35'	TQ	1200	250
	Shoubak	Ghair	30˚ 32'	35˚ 35'	SG	1460	315
	Maán2	Basta	30˚ 13'	35˚ 31'	MB	1420	250

Table (2): Ranges, means, standard deviation and F values of lines for 12 characters for 920 lines of durum wheat landraces at the two test locations Mu'tah University Agricultural Station (MUAS) and Ghweer Agricultural Station (GAS).

Trait	Location	Min.	Max.	Mean	S. D. (±)	F-value for accessions	$LSD_{0.05}$
Plant height (cm)	MUAS	53.50	116.00	88.40	9.80	2.19**	18.45
	GAS	35.00	96.00	76.33	9.07	2.12**	17.38
Grain yield (g plant^{-1})	MUAS	0.44	64.40	8.50	4.4	3.69**	7.16
	GAS	0.67	28.33	7.33	12.8	2.19**	8.44
Biological yield (g plant^{-1})	MUAS	2.20	79.90	24.90	12.80	2.63**	24.16
	GAS	0.80	93.83	19.91	9.97	1.93**	19.93
Straw yield (g plant^{-1})	MUAS	0.09	61.70	16.80	9.10	2.54**	17.97
	GAS	012	79.45	13.24	7.09	2.18**	13.62
Harvest index	MUAS	0.08	0.69	0.34	0.07	1.82**	0.13
	GAS	0.03	0.68	0.35	0.07	1.95**	0.17
Number of spikes plant^{-1}	MUAS	1.00	19.00	5.87	2.65	2.63**	5.02
	GAS	1.00	19.50	5.71	2.46	1.73**	5.20

Trait	Location	Min.	Max.	Mean	S. D. (±)	F-value for accessions	LSD$_{0.05}$
Number of kernels spike^{-1}	MUAS	8.11	81.67	34.40	8.49	1.68**	19.50
	GAS	5.10	70.25	30.91	9.52	19.50**	20.56
Hundred kernel weight	MUAS	1.46	6.15	4.14	0.55	1.79**	1.15
	GAS	1.20	7.25	3.95	0.55	3.17**	2.04
Average spike weight (g)	MUAS	0.49	3.81	2.08	0.45	1.40**	1.05
	GAS	0.41	3.67	1.88	0.43	2.29**	1.88
Days to heading (days)	MUAS	107.00	135.50	119.34	3.73	2.09**	7.16
	GAS	73.00	99.00	80.24	3.62	2.76**	6.05
Days to maturity (days)	MUAS	156.00	171.00	161.31	3.57	1.98**	7.03
	GAS	105.50	121.00	111.69	2.48	2.31**	4.53
Grain filling period (days)	MUAS	28.50	55.50	41.93	3.57	1.15**	8.20
	GAS	18.00	41.00	31.53	3.09	1.78**	6.56

Table (3): Estimates of variance components, broad sense heritability (h^2), phenotypic (PCV) and genotypic coefficients of variation (GCV), genetic advance (GA) and GA as a percentage of mean (GA%) for 12 traits of 920 lines of durum wheat landraces, combined across two locations.

Trait	PCV (%)	GCV (%)	Variance components			h^2	GA	GA (%)
			Lines	Lines × Loc.	Error			
Plant height (cm)	9.08	5.72	22.08**	25.36**	41.78	39.68	6.10	7.42
Grain yield (g plant^{-1})	41.67	17.67	1.90**	9.44**	7.89	18.01	1.20	15.44
Biological yield (g plant^{-1})	38.15	15.30	11.57**	57.42**	63.32	16.08	2.81	12.64
Straw yield (g plant^{-1})	41.50	18.88	7.83**	27.11**	32.89	20.71	2.62	17.70
Harvest index	16.38	5.88	4.00×10^{-4}*	2.3×10^{-3}**	3.10×10^{-3}	13.49	0.01	4.35
Number of spikes plant^{-1}	34.20	17.87	1.07**	2.33**	3.37	27.29	1.11	19.23
Number of kernels spike^{-1}	20.22	4.69	2.31	29.36**	51.73	5.38	0.73	2.24

Trait	**PCV (%)**	**GCV (%)**	**Variance components**			**h^2**	**GA**	**GA (%)**
			Lines	**Lines × Loc.**	**Error**			
Hundred kernel weight	10.91	5.70	0.052**	-0.075	0.35	27.27	0.24	6.13
Average spike weight (g)	16.15	5.13	0.010^{+}	-0.115	0.297	10.08	0.07	3.35
Days to heading (days)	2.97	2.00	3.97**	3.97**	5.66	45.19	2.76	2.77
Days to maturity (days)	1.81	1.18	2.58**	2.46**	4.53	42.45	2.16	1.58
Grain filling period (days)	6.81	2.80	1.05**	3.23*	7.11	16.85	0.87	2.37

$^{+}$, *, ** Significant at the 0.1, 0.05 and 0.01 probability level, respectively.

Table (4): Estimates of variance components, phenotypic (PCV) and genotypic coefficients of variation (GCV), broad sense heritability (*h^2*), genetic advance (GA) and GA as a percentage of mean (GA%) for 12 characters of 920 durum wheat landrace lines at the two test locations Mu'tah University Agricultural Station (MUAS) and Ghweer Agricultural Station (GAS).

Trait	**Loc.**	**PCV (%)**	**GCV (%)**	**Source of variance**			**h^2**	**GA**	**GA (%)**
				V_{ph}	**V_g**	**V_e**			
Plant height (cm)	MUAS	13.44	8.22	141.12	52.76	88.36	37.38	9.15	10.35
	GAS	14.49	8.68	122.30	43.88	78.42	35.88	8.17	10.71
Grain yield (g plant^{-1})	MUAS	65.69	49.74	31.17	17.87	13.30	57.33	6.59	77.58
	GAS	74.06	45.19	29.47	10.97	18.50	37.23	4.16	56.80
Biological yield (g plant^{-1})	MUAS	66.63	44.65	275.23	123.63	151.60	44.92	15.35	61.65
	GAS	61.70	34.70	150.91	47.74	103.17	31.64	8.01	40.21
Straw yield (g plant^{-1})	MUAS	72.50	47.82	148.35	64.53	83.81	43.50	10.91	64.97
	GAS	66.05	40.21	76.48	28.34	48.14	37.06	6.68	50.42
Harvest index	MUAS	23.89	12.82	6.6×10^{-3}	1.90×10^{-3}	4.70×10^{-3}	28.79	0.05	14.17
	GAS	29.69	16.90	1.08×10^{-2}	3.50×10^{-3}	7.30×10^{-3}	32.41	0.07	19.82
Number of spikes plant^{-1}	MUAS	58.68	39.34	11.87	5.33	6.53	44.94	3.19	54.33
	GAS	54.17	27.96	9.57	2.55	7.02	26.65	1.70	29.73
Number of kernels spike^{-1}	MUAS	33.45	16.87	132.41	33.69	98.72	25.44	6.03	17.53
	GAS	41.65	24.21	165.74	56.00	109.74	33.79	8.96	28.99
Hundred kernel weight	MUAS	16.74	8.89	0.48	0.14	0.34	28.21	0.40	9.73
	GAS	38.03	27.44	2.26	1.17	1.08	52.06	1.61	40.79

Trait	Loc.	PCV (%)	GCV (%)	Source of variance			h^2	GA	GA (%)
				V_{ph}	V_g	V_e			
Average spike weight (g)	MUAS	28.05	11.44	0.34	0.06	0.28	16.63	0.20	9.61
	GAS	65.37	40.97	1.51	0.59	0.92	39.28	0.99	52.90
Days to heading (days)	MUAS	3.80	2.26	20.57	7.28	13.29	35.37	3.30	2.77
	GAS	5.27	3.61	17.90	8.38	9.52	46.82	4.08	5.09
Days to maturity (days)	MUAS	2.71	1.56	19.15	6.32	12.83	32.99	2.97	1.84
	GAS	2.66	1.68	8.84	3.51	5.33	39.67	2.43	2.17
Grain filling period (days)	MUAS	11.15	5.01	21.87	4.41	17.45	20.18	1.94	4.64
	GAS	12.51	6.62	15.55	4.36	11.19	28.05	2.28	7.23

Table (5): Phenotypic correlation coefficients among various pairs of the 12 tested traits in 920 durum wheat landraces lines at the two test locations Mu'tah University Agricultural Station (MUAS) and Ghweer Agricultural Station (GAS).

No.	Trait	Loc.	2	3	4	5	6	7	8	9	10	11	12
1	Plant height (cm)	MUAS	0.47**	0.60**	0.58**	-0.11**	0.49**	0.09**	0.30**	0.41**	0.07**	-0.04	-0.12**
		GAS	0.35**	0.51**	0.44**	0.05	0.39**	0.11**	0.14**	0.18**	-0.29**	0.37**	0.37**
2	Grain yield (g plant^{-1})	MUAS		0.81**	0.71**	0.20**	0.76**	0.22**	0.30**	0.36**	-0.04	-0.12**	-0.08*
		GAS		0.68**	0.26**	0.39**	0.59**	0.50**	0.28**	0.20**	-0.17**	0.01	0.20**
3	Biological yield (g plant^{-1})	MUAS			0.96**	-0.11**	0.91**	0.09**	0.20**	0.34**	-0.04	-0.18**	-0.13**
		GAS			0.91**	0.00	0.84**	0.14**	0.04	0.24**	-0.17**	0.07*	0.25**
4	Straw yield (g plant^{-1})	MUAS				-0.26**	0.86**	0.05	0.14**	0.27**	-0.03	-0.17**	-0.13**
		GAS				-0.24**	0.77**	0.00	0.05	0.20**	-0.09**	0.07*	0.16**
5	Harvest index	MUAS					-0.06	0.41**	0.33**	0.26**	-0.03	0.03	0.06
		GAS					-0.02	0.58**	0.33**	-0.03	-0.21**	-0.07*	0.17**
6	Number of spikes plant^{-1}	MUAS						-0.09**	0.09**	0.10**	-0.09**	-0.19**	-0.10**
		GAS						-0.05	0.00	-0.03	-0.14**	0.16**	0.16**
7	Number of kernels spike^{-1}	MUAS							0.05	0.56**	0.11**	0.02	-0.10**
		GAS							0.04	0.29**	-0.11**	0.15**	0.15**
8	Hundred kernel weight	MUAS								0.40**	-0.05	0.02	0.07*
		GAS								0.03	-0.04	0.00	0.05
9	Average spike weight (g)	MUAS									0.12**	0.06	-0.06
		GAS									-0.11**	0.01	0.14**
10	Days to heading (days)	MUAS										0.51**	0.53**
		GAS										0.51**	0.74**
11	Days to maturity (days)	MUAS											0.46**
		GAS											0.20**
12	Grain filling period (days)	MUAS											1
		GAS											1

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

Table (6): Number (N) and frequency of lines which significantly exceeded the best standard check at the two test locations Mu'tah University Agricultural Station (MUAS) and Ghweer Agricultural Station (GAS).

Trait	Loc.	Total number of lines test	Means of checks							Number (N) and frequency (%) of lines significantly exceeding the best check	
			Haurani 27	Acsad 65	Om Qais	Sham 3	Sham 1	Sham 5	Deiralla 6	N	%
Plant height	MUAS	920	87.21	83.1	85.47	84.37	75.40	83.94	84.27	23	2.50
	GAS	920	74.85	62.43	67.22	66.31	65.80	66.78	56.35	9	1.00
Grain yield (g plant^{-1})	MUAS	920	5.58	6.61	8.05	7.16	5.87	7.80	8.89	54	5.87
	GAS	920	6.74	5.41	5.71	4.93	6.43	5.74	3.47	53	5.76
Biological yield (g plant^{-1})	MUAS	920	17.55	19.81	26.00	22.71	17.10	24.19	35.65	24	2.61
	GAS	920	15.11	16.19	15.26	14.28	18.42	16.16	9.097	40	4.35
Straw yield (g plant^{-1})	MUAS	920	11.97	13.19	17.99	15.54	11.70	17.23	26.47	19	2.07
	GAS	920	9.24	10.78	9.09	9.32	14.26	10.69	8.09	32	3.47
Number of spikes plant^{-1}	MUAS	920	5.01	5.16	5.60	6.10	5.07	5.85	5.41	49	5.33
	GAS	920	4.82	5.29	5.12	4.57	5.69	4.35	3.49	33	3.59
Number of kernels spike^{-1}	MUAS	920	34.12	32.96	37.75	31.72	28.49	35.53	39.72	14	1.52
	GAS	920	34.87	27.04	34.20	28.61	27.41	34.93	26.45	25	2.72
Hundred kernel weight	MUAS	920	3.92	4.01	4.03	3.76	3.83	3.90	4.23	25	2.71
	GAS	920	4.64	3.64	3.35	3.58	3.85	3.49	3.61	5	0.54
Days to heading (days)	MUAS	920	118.90	116.30	119.10	118.39	119.32	117.13	121.87	9	1.00
	GAS	920	78.50	79.92	80.11	80.69	79.55	82.00	84.10	5	0.54

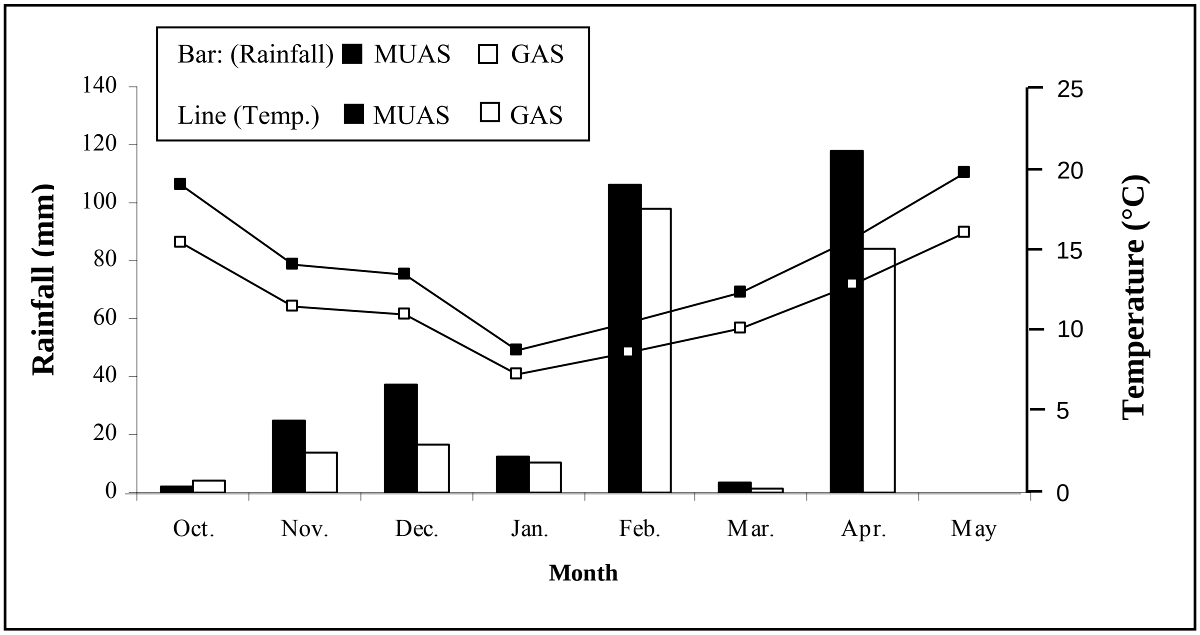

Figure (1): Monthly rainfall and mean temperature (°C) during 2005/2006 growing season at the two test locations; Mu'tah University Agricultural Station (MUAS) and Ghweer Agricultural Station (GAS).

REFERENCES

Abdel-Ghani, A.H., Duwayri, M. and Kafawin, O. 2000. Phenotypic diversity among wheat landraces from Jordan: morphological and developmental traits. ***Rachsis,*** 18: 31-38.

Abdel-Ghani, A.H., Parzies, H.K., Ceccarelli, S., Grando, S. and Geiger, H.H. 2005. Estimation of quantitative genetic parameters for outcrossing-related traits in barley. ***Crop Science***, 45: 98-105.

Allard, R.W. 1999. Principles of plant breeding, 2nd edn. New York: John Wiley and Sons.

Anscombe, F.J. and Tukey, J.W. 1963. The examination and analysis of residuals. ***Technometrics,*** 5: 141-160.

Arboleda-Rivera, F. and Compton, W.A. 1974. Differential response of maize (*Zea mays* L.) to mass selection in diverse selection environments. ***Theoretical and Applied Genetics***, 44: 137-142.

Atlin, G.N. and Frey, K.G. 1990. Predicting the relative effectiveness of direct versus indirect selection for oat yield in three types of stress environments. ***Crop Science,*** 30: 556-561.

Bayder, H., Marquard, R. and Turgut, I. 1999. Pure line selection for improved yield, oil content and different fatty acid composition of sesame, *Sesamum indicum*. ***Plant Breeding***, 118: 462-464.

Belay, G., Tesemma, T., Becker, H.C. and Merker, A. 1993. Variation and interrelationships of agronomic traits in Ethiopian tetraploid wheat landraces. ***Euphytica***, 71: 181-188.

Bhatt, G.M. 1973. Significance of path coefficient analysis in determining the nature of character association. ***Euphytica***, 22: 338-343.

Ceccarelli, S. 1987. Yield potential and drought tolerance of segregating populations of barley from contrasting environments. ***Euphytica,*** 92: 203-214.

Ceccarelli, S. 1989. Wide adaptation. How wide?. ***Euphytica,*** 40: 197-205.

Ceccarelli, S. 1994. Specific adaptation and breeding for marginal conditions. ***Euphytica***, 77: 205-219.

Ceccarelli, S. 1996: Adaptation to low/high input cultivation conditions. ***Euphytica,*** 92: 203-214.

Ceccarelli, S. and Grando, S. 2000: Barley landraces from the Fertile Crescent: a lesson for plant breeders. In ***Genes in the Field: on-farm conservation of crop diversity***, edited by Brush, S. B., pp. 51-76. Lewis Publisher, Boca Raton; Fl, USA.

Chapman, S.C., Cooper, M.C., Hammer, G.L. and Butler, D. 2000. Genotype by environment interactions affecting grain sorghum. II. Frequencies of different seasonal patterns of drought stress are related to location effects on hybrid yields. ***Australian Journal of Agricultural Research***, 51: 209-222.

Damania, A.B. 1989. Genetic resources of wild relatives in cereals crops. I. Germplasm sampling strategy. ***Rachis***, 9: 8-10.

Duwayri, M., Migdadi, H., Sadder, M., Kafawin, O., Ajlouni, M. and Nachit M. 2007. Use of SSR markers for characterizing cultivated durum wheat and its naturally occurring hybrids with wild wheat. ***Jordan Journal of Agricultural Sciences***, 3: 398-410.

Ehdaie, B. and Waines, J.G. 1989. Genetic variation, heritability and path coefficient analysis in landraces of bread wheat from southwestern Iran. ***Euphytica***, 41: 183-190.

Ehdaie, B., Waines, J.G. and Hall, A.E. 1988. Differential responses of landrace and improved spring wheat genotypes to stress environments. ***Crop Science***, 28: 838-842.

Eticha, F., Getachew, B. and Bekele, E. 2006. Species diversity in wheat landrace populations from two regions of Ethiopia. ***Genetic Resources and Crop Evolution***, 53: 387-393.

Fehr, W.R. 1987. Principles of cultivar development. Vol. I. New York: Macmillan.

Frankel, H., Burdon, J.J. and Peacock, W.J. 1995. Landraces in transit- The threat perceived. ***Diversity***, 11: 14-15.

Frey, K.J. 1964. Adaptation reaction of oat strains selected under stress and non-stress environmental conditions. ***Crop Science***, 4: 55-58.

Getachew, B., Tessema, T., Becker, H.C. and Merker, A. 1993. Variation and interrelationships of agronomic traits in Ethiopian tetraploid wheat landraces. ***Euphytica***, 71: 181-188.

Harlan, J.R. 1975. Our vanishing genetic resources. ***Science***,188: 618-621.

Haussmann, B.I.G., Obilana, A.B., Ayiecho, P.O., Blum, A., Schipprack, W. and Geiger, H.H. 2000. Yield and yield stability of four population types of grain sorghum in a semi-arid area of Kenya. ***Crop Science***, 40: 319–329.

Hawkes, J.G. 1977. The importance of wild germplasm in plant breeding. ***Euphytica***, 26: 615-621.

Jaradat, A.A. 1991. Levels of phenotypic variation for developmental traits in landraces genotypes of durum wheat (*Triticum turgidum* ssp. *turgidum* L. Conv. *durum* (Desf.) Mk.) from Jordan. ***Euphytica***, 51: 265-271.

Jaradat, A.A. 1992. Breeding potential of durum wheat landraces from Jordan II. Differential response to drought. ***Hereditas***, 116: 305-309.

Jaradat, A.A., Shahid, M. and Al Maskri, A.Y. 2004. Genetic diversity in the Batini barley landrace from Oman II. Response to salinity stress. ***Crop Science***, 44:997-1007.

Jaradat, A.A., Shahid, M. and Al Maskri, A.Y. 2005. Genetic diversity in the Batini barley landrace from Oman I. Spike and seed quantitative and qualitative traits. ***Crop Science***, 44: 304-315.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybeans. ***Agronomy Journal***, 47: 314-318.

Kebebew, F., Tsehaye, Y. and Mcneilly, T. 2001. Diversity of durum wheat (*Triticum durum* Desf.) at *in situ* conservation sites in North Shewa and Bale, Ethiopia. ***The Journal of Agricultural Science***, 136: 383-392.

Kumar, A., Misra, S.C., Singh, Y.P. and Chauhan, B.P.S. 1985. Variability and correlation studies in triticale. ***Journal of Maharashtra Agricultural Universities***, 10: 273-275.

Laing, D.R. and Fisher, R.A. 1979. Adaptation of semidwarf wheat cultivars to rainfed conditions**.** ***Euphytica***, 26: 129-139.

Negassa, M. 1985. Patterns of phenotypic diversity in an Ethiopian barley collection, and the Arussi-Bale Highland as a center of origin of barley. ***Hereditas***, 102: 139-150.

Ouk, M., Basnayake, J., Tsubo, M., Fukai S., Fischer, K.S., Kang, S., Men, S., Thun, V. and Cooper, M. 2006. Genotype-by-environment interactions for grain yield associated with water availability at flowering in rainfed lowland rice. ***Field Crops Research***, 101: 145-154.

Roy, N.N. and Murty, B.R. 1970. A selection procedure in wheat for stress environment. ***Euphytica***, 19: 509-521.

Shoaib, A. and Arabi, M.I.E. 2006. Genetic diversity among Syrian cultivated and landraces wheat revealed by AFLP markers. ***Genetic Resources and Crop Evolution***, 53: 901-906.

Sidwell, R.J., Smith, E.L. and McNew, R.W. 1976. Inheritance and interrelationships of grain yield and selected yield-related traits in hard red winter wheat cross. ***Crop Science***, 16: 650-654.

Snedecor, G.W. and Cochran, W.G. 1980. Statistical methods. 7th ed. Iowa State Univ. Press.

Tesfaye, T., Getachew, B. and Worende, M. 1991. Morphological diversity in tetraploid wheat landrace populations from the central highlands of Ethiopia. ***Hereditas***, 114: 171-176.

Utz, H.F. 2000. PLABSTAT: A computer program for the statistical analysis of plant breeding experiments. Version 2N. Institute of Plant Breeding, Seed Science, and Population Genetics, University of Hohenheim, Stuttgart, Germany.

Virk, D.S. and Mangat, B.K. 1991. Detection of cross-over genotype × environment interactions in pearl millet. ***Euphytica***, 52: 193-199.

Weltzien, E. 1988. Evaluation of barley (*Hordeum vulgare* L.) landrace populations originating from different growing regions in the Near East. ***Plant***

Breeding, 101: 95-106.

Weltzien, E. and Fischbeck, G. 1990. Performance and variability of local barley landraces in near-eastern environments. ***Plant Breeding***, 104: 58-67.

Woodend, J.J. and Glass, A.D.M. 1993. Genotype-environment interaction and correlation between vegetative and grain production measures of potassium use-efficiency in wheat (*T. aestivum* L.) grown under potassium stress. ***Plant and Soil***, 151: 39-44.

Wricke, G. and Weber, W.E.. 1986. Quantitative genetics and selection in plant breeding. Berlin: Walter de Gruyter and Co.

Yifru, T., Hammer, K., Huang, X.Q. and Röder, M.S. 2006. Regional patterns of microsatellite diversity in Ethiopian tetraploid wheat accessions. ***Plant breeding***, 125: 125-130.

تقدير التباين الوراثي ومعامل التوريث وعوامل الارتباط للصفات الشكلية لسلالات القمح القاسي من الأردن

عادل حسن عبد الغني[*]

ملخـص

تم تقييم 920 سلالة نقية من القمح القاسي جمعت من عشر مناطق مختلفة من الأردن، بالإضافة إلى سبعة أصناف من القمح القاسي المزروع محليا (حوراني 27 وأكساد 65 وأم قيس وشام 3 وشام 1 وشام 5 ودير علا 6) . تم اجراء التجربة تحت الظروف الجافة وشبة الجافة بزراعة سنبلة واحدة (سلالة) لكل خط. هدفت التجربة إلى تقدير معامل التشتت للطرز الشكلية ومعامل التشتت الجيني ومعامل التوريث بمعناه الواسع والتحصيل الوراثي لصفات المحصول المختلفة باستخدام تحليل التباين المشترك واعتمادا على تحليل التباين لكل منطقة على حدة. كما هدفت الدراسة إلى تقدير معامل الارتباط مابين الصفات النباتية المختلفة. كانت قيم معامل التشتت الجيني ومعامل التوريث والتحصيل الوراثي باستخدام التحليل المشترك للصفات المختلفة اقل مقارنة بالقيم المحسوبة على أساس تحليل التباين لكل موقع على حدة. إن ارتفاع قيم التداخل مابين الأصناف والمواقع قد تؤدي إلى صعوبة في عملية الانتخاب، ذلك لأن انتخاب سلالات عالية الإنتاج تحت الظروف المثالية ليس بالضرورة أن تكون أعلى إنتاجا تحت الظروف الصعبة والعكس صحيح، لذلك فإن إجراء الانتخاب تحت ظروف البيئة المستهدفة هو الأكثر كفاءة. كانت قيم معامل التشتت للطرز الشكلية ومعامل التشتت الوراثي ومعامل التوريث بمعناه الواسع ومقدار التحصيل الوراثي (على أساس النسبة من المتوسط) متوسطة إلى عالية لصفة إنتاج الحب للنبات الواحد والإنتاج البيولوجي للنبات الواحد وإنتاج القش للنبات الواحد وعدد السنابل ومحتوى السنبلة من الحب ووزن المائة حبة ومعدل وزن السنبلة. وكانت معاملات الارتباط لإنتاج الحب للنبات الواحد مع عدد السنابل للنبات الواحد ومحتوى السنبلة من الحب ووزن المائة حبة ومعدل وزن السنبلة موجبة، مما يدل على إمكانية زيادة الإنتاج عن طريق الانتخاب غير المباشر لعدد السنابل ومحتوى السنبلة من الحب ووزن المائة حبة ومعدل وزن السنبلة، وكانت معاملات الارتباط لإنتاج الحب مع وقت الإزهار ووقت النضج وفترة امتلاء الحبوب سالبة، مما يدل على أهمية التبكير في الإزهار للحصول على إنتاجية عالية تحت ظروف الجفاف. أظهرت بعض السلالات المدروسة تفوقا معنويا عند مقارنتها مع الأصناف المزروعة محليا، مما يدل على وجود بعض السلالات المتميزة التي يمكن استغلالها في برامج التهجين. تشير هذه الدراسة الى إمكانية زيادة إنتاجية السلالات المحلية من القمح عن طريق الانتخاب غير المباشر لمكونات الحاصل أو عن طريق الانتخاب المباشر لصفة الإنتاج.

الكلمات الدالة: السلالات المحلية، السلالات النقية، القمح القاسي، الانتخاب.

---

[*] قسم الإنتاج النباتي، كلية الزراعة، جامعة مؤتة، ص. ب. (7)، الكرك، الأردن.

تاريخ استلام البحث 2008/4/27 وتاريخ قبوله 2008/7/21.