Jordan Journal of Agricultural Sciences, Volume **13**, No.**1** 2017

Effect of Pre-Anthesis Water Deficit on Plant Height, Peduncle Length and Spike Length in 13 Barely (*Hordeum vulgare* L.) Genotypes

Zakaria I. Al-Ajlouni[1✉], Abdul Lataif A. Al-GhzawiI[2,] Ayed M. Al-Aabdallat[3,4], Jamal Y. Ayad[2],

Jamal M. Abu Elenein[2], Nisreen A. Al-Quraan[5], P. Stephen Baenziger[6]

ABSTRACT

A total of 13 barley genotypes were grown in a Randomized Complete Block Design using 6 replications to study the effect of pre-anthesis water deficit on plant height, peduncle length and spike length. Significant differences were observed amongst genotypes regarding all the characters studied. Genotypic variability was higher than the G X E. Results indicated diverse effect of the non-stressed and stressed environments overall genotypes on the studied traits. At non-stress condition, mean plant height was (67 cm) and was significantly higher than the stressed environment. Overall treatments, Morex was the tallest plant and had the longest peduncle (77.6 cm and 3.78 cm, respectively). Whereas Ubi is the shortest and MF had the shortest peduncle. Tadmor had the longest spike (7.95 cm) while Steptoe had the shortest spikes.

Keywords: Drought, Jordan, stem elongation, yield, selection.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is an important cereal crop grown widely throughout the world's temperate agricultural zones (Wang et al., 2010). It is one of the most important field crops in Jordan. Barley is adapted to harsh environments and low soil fertility compared to other cereal crops. It is mainly grown for food, feed, and malt **(**von Bothmer et al., 2003; Wahbi and Sinclair, 2005). In Jordan, yield damages occurred due to drought resulted from either low or unequal distribution of precipitation during the whole plant growth cycle (Ceccarelli and Grando, 1996). In other words, drought might happen during pre-anthesis as well as post anthesis period. Few reports in the literature discuss the effect of pre-anthesis water deficit on barley production.

If soil moisture is too little at sowing time, which is the case in rainfed arid and semi-arid environments, this will result in poor germination and seedling establishment, poor tillering and hence, smaller number of plants per unit area and lesser growth potential (Dodig, et al., 2014). Additionally, drought at the period of stem elongation (pre-anthesis) causes reduction in number of grains per unit area due to it is harmful effect on floret fertility (Fischer & Turner, 1978; Dodig, et al., 2014). Jordan is potentially very subjected to future changes in climate, which will possibly cause an increase in frequent drought stress, which will consequently affects barley production (Samarah, 2005; Ceccarelli, et al., 2010).

Under pre-anthesis water-limited conditions, Yield

[1] Department of Plant Production, College of Agriculture, Jordan University of Science and Technology, P. O. Box 3030, Irbid 22110, Jordan. ✉ziajlouni@just.edu.jo
[2] Department of Biology and Biotechnology, Faculty of Science, The Hashemite University, Zarqa, Jordan
[3] Department of Horticulture and Crop Science, Faculty of Agriculture, The University of Jordan, Amman 11942, Jordan
[4] International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 950764, Amman 11195, Jordan
[5] Department of Biotechnology and Genetic Engineering, Faculty of Science and Arts, Jordan University of Science and Technology, P. O. Box 3030, Irbid 22110, Jordan
[6] Department of Agronomy and Horticulture, 362D Plant Science Building, 1875 N. 38th Street, University of Nebraska, Lincoln, NE 68583-0915, USA.
Received on 26/1/2016 and Accepted for Publication on 26/5/2016.

"as a quantitative trait" can be increased indirectly via targeting some morphological traits such as plant height, peduncle length and spike length (Bogale et al., 2011). For example peduncle length has been suggested as a useful indicator of yield capacity in dry environments (Niari Khamssi and Najaphy, 2012). Moreover, Asseng & van Herwaarden, (2003) reported that peduncle length has a role in stem reserve remobilization & was correlated with high grain yield under heat stress. Furthermore, peduncle length was highly sensitive to heat stress and decreased by 10.62% (Villegas et al. 2007). The role of wheat peduncle length in heat and drought tolerence was already proved due to its role in photosynthesis and stem reserve remobilization (Villegas et al. 2007).

Plant height is an important reflection for many cereal growers and plant breeders developing cultivars to meet grower needs (Budak et al., 1995; Shakhatreh et al., 2001; Baenziger et al., 2004). Plant height in barley and its relationship to grain yield has long been of interest to plant breeders. However, tall cultivars are more prone to lodging, particularly when grown in favorable environments, whereas semidwarf cultivars are shorter, less prone to lodging and usually partition more dry-matter to the grain (have a higher harvest index, Waddington et al., 1986; Bingham et al., 2007). Several genes for height reduction have been reported in barley (Zhang et al., 2006). Therefore, increasing drought tolerance at stem elongation and tillering stages must be targeted in breeding new varieties for dry areas. The purpose of this research is to improve our understanding of how to select suitable plant height, peduncle length, and spike length for barley genotypes at low rainfall dry land in Jordan and the information about these traits variability in this crop would be of a great value to improve selection.

MATERIALS AND METHODS

The experiment was conducted in a glasshouse located in the Jubiha research station of the Faculty of Agriculture at University of Jordan/Amman/Jordan. Thirteen barley genotypes originated from different regions including (Jordan, ICARDA, UK, USA, Germany, Australia) were used in the present study in order to compare their performance when grown under pre-anthesis water stress conditions. Four of them were Jordanian cultivars (Acsad176, Rum, Muta' and Yarmouk) and 9 were international cultivars (Morex, Steptoe, Keel, Arta, Golden promise (GP), Tadmor, ER/Amp, MF, and Ubi). The 13 genotypes were selected to maximize genetic diversity of pre-anthesis drought adaptation. Jordanian genotypes mainly characterized as following Acsad176 is characterized by medium height and produces short spikes. Under semi-arid condition in Jordan, Acsad176 is grown but with supplementary irrigation while under good conditions it produces vigorous vegetative growth coupled with flattened wide leaves (Al-Rawashdeh, et al., 2013). Mutah is a released Jordanian cultivar, developed at ICARDA and has long spikes with smooth awns (Al-Rawashdeh, et al., 2013). Rum is characterized by medium height, production of large number of tillerrs, early to medium flowering and fast filling, has short spikes and large grain size. Adapted and strong tolerant to drought stress in semi-arid regions of Jordan (Al-Rawashdeh, et al., 2013; Samarah, 2005). Yarmouk is a released Jordanian cultivar, developed at ICARDA, tolerates drought and have long spikes and smooth awns (Al-Rawashdeh, et al., 2013).

The international genotypes were characterized as following Arta is a high tillering cultivar with big spike and large grains. It has vigorous growth and good tolerance. It is very short under drought conditions (Mazid, et al., 2007). ER/Amp is a 2-row type selected in ICARDA and released in Tunisia. Golden promise (GP) is a semi-dwarf UK cultivar with salt tolerant, fast maturing and superior malting variety (Kapusi, 2010). Tadmor is a 2-row type collected from a field of Arabi

Aswad in ICAEDA. Keel: is a high yielding with an early flowering and early maturing Australian cultivar. Keel characterized by improved straw strength, moderate resistant to head loss and is easy to thresh, heavier grains with moderate size and it has good leaf disease resistance. It does well in heavy soil types with lower rainfall but it suffered at lower fertile sandy soils (Horsham, 2011). Morex is a tall with nearly weak straw but resistant to lodging and has attractive malting and brewing features. Morex is superior to yield, and disease resistance to stem rust and loose smut and spot blotch (Robertson, et al., 2003). Steptoe is a high-yielding cultivar with erect spikes, large white-grains. Steptoe is acclimatized to the high rainfall areas (Robertson, et al., 2003).

The barley genotypes were grown in a glasshouse equipped with ventilation system to keep the temperature around 25/18 °C (day/night) and relative humidity at70%. Seeds of the genotypes were grown in pots (40 cm length and 30 cm in diameter). The pots were filled with a mixture of soil and peat-moss (2:1 ratio). Initially and after seed sowing, which took place in the 1st of November 2012, the soil moisture content in the pots was brought to field capacity by irrigation with tap water. After seedling emergence, plants were exposed to two water regimes: "non-stressed" in which irrigation water were applied when soil moisture reaches a level of 20% water depletion of field capacity and "stressed" in which irrigation after soil moisture reached 20% water depletion of the field capacity and then brought back to 50% of field capacity. The stress treatment was applied to barley plants at two different pre-anthesis growth stages: tillering stage (SS) (Zadoks et al., 1974 and stem elongation stage (SE); forth node detectable.

Treatment combinations were set as a factorial arrangement 13 Genotype x 3 water regimes] in a randomized completely block design (RCBD) with six replications and each rep was composed from 1 pot with one biological sample per pot. Each trait was calculated from five samples Plant height (cm), Peduncle length (cm) and Spike length (cm) were recorded per plant. Plant height (cm) was measured for each genotype at maturity from the ground level to the spike tip (excluding awns). At maturity peduncle length (cm) and spike length (cm) were measured. Peduncle length (cm) measured from last node to the ligule of flag leaf. When the value is negative, this indicates that the spike remained inside the sheet of flag leaf. Spike length (cm) from selected main shoot was measured in centimeters from base of the spike to its tip without awns.

The data collected were then subjected to statistical analysis including analysis of variance (ANOVA), correlation coefficient and least significant difference (LSD). ANOVA were statistically analyzed using SAS software version 9.1 to determine the significant differences between genotypes, treatments and the genotype and environment interaction. While, the means were separated using the least standard error of the differences between means (LSD 0.05). The relationships between peduncle length, spike length, plant height and grain yield in relation to drought tolerance were assessed using correlation coefficient.

RESULTS AND DISCUSSIONS

Combined analysis of variance showed highly significant differences between treatments, genotypes and their interaction (G X E) for all measured traits (Table 1). These findings were agreed with Budak et al., (1995); Babaiy et al., (2011) and Amiri et al., (2013). The significant effect of G X E indicated that the genotypes responded differently to the various non-stressed and stressed conditions represented by the 3 environments. This was consistent with Francia et al., (2011) who reported that cereal stability under variable Mediterranean conditions was highly dependent on the effect of genotype, environment and their interaction. Indeed, current study showed that the mean squares of stress treatment (environments) for all measured traits was greater than the G X E mean square (Table 1).

A higher environmental effect was expected and confirmed the negative effect of pre-anthesis water deficit on each of plant height, peduncle length and spike length. Plant height had a higher G X E effect compared to the G X E for peduncle length and spike length that may reflect the greater selection emphasis on plant height for local adaptation than on peduncle and spike lengths. For plant height, the mean squares of G X E were smaller than the mean square of genotype indicating that the genotypic effects were also more important than G X E which agreed with Budak et al., (1995). Similar trend was seen for peduncle length and spike length (Table 1).

For non-stress environment, Morex and Steptoe were the tallest (95.4 cm and 79.4 cm respectively), while Ubi and MF were the shortest (48.5 cm and 55.4 cm, respectively) (Table 2, Figure 1). With regard to peduncle length, Morex and ER/Apm had the longest peduncles (8.4 and 5.4, respectively), while MF and Steptoe had the shortest peduncle (-7.8 and -5.7, respectively) (Table 2, and figure 2). For Spike length, Tadmor and Muta' (8.8 cm and 8.5 cm, respectively) had the longest spike while Steptoe and MF had the shortest spike (5.2 and 5.3 cm, respectively) (Table 2). Plant height, peduncle length and spike length were negatively ($P<0.05$) affected by pre-anthesis drought stress at both of stem elongation stage (SE) seedling stage (SS) and (Table2).

When Drought stress was applied at stem elongation stage, Morex and Rum were the tallest (72.8cm and 57.5 cm, respectively) while Ubi and Steptoe were the shortest (32.2 cm and 39.9 cm, respectively) (table 2 and figure 1). Morex also had the longest peduncle (4.1 cm) while MF and Keel had the shortest peduncle (-6.8 and -6.5 cm, respectively) (table 2 and figure 2). Meanwhile, Tadmor and Yarmouk had the longest spikes (7.4 cm and 7.2 cm, respectively), while Steptoe had the shortest spike (3.0 cm) (Table 2).When drought was applied at tellering stage (SS), Morex, Rum and Steptoe were the tallest (64.4 cm, 57.3 cm and 52.5 cm, respectively) amongst all 13 genotypes, while Ubi, MF and Arta were the shortest (35 cm, 39.4 cm and 39.6 cm, respectively) (Figure 1). On the other hand, Morex (-1.2cm) and Rum (-0.1cm) had the longest peduncle, while MF (-10.5 cm) and Steptoe (-8.7 cm) had the shortest peduncle amongst all tested genotypes (Table 2 and Figure 2). With regard to spike length Morex (8.1 cm), Tadmor (7.8 cm) and Muta' (7.6 cm) had the longest spikes, while Steptoe (3.7 cm), Rum (4.8 cm) and Acsad176 (4.9 cm) had the shortest spikes (Table 2). Present results were consistent with findings of Zare et al (2011) who found that drought stress reduced plant height and spike length. Combined analysis of variance across environments revealed that stress effects were significant for all traits, indicating that these traits are influenced by drought stress conditions. Similar results have been reported by Naghaii and Asgharipour (2011), who reported a significant difference among stress conditions for plant height. Present results were in agreement with those of Flintham et al., 1997; Talebi et al., (2009); Amiri et al (2013); Zare et al (2011) who showed that the genotypes differs significantly in plant height, Peduncle length and spike length.

Based on the results of the correlation coefficients, no significant correlation was found between grain yield and plant height under each of NS, SS and SE treatments (Table 3). These results were consistent with findings of Amiri et al., (2013) and Babaiy et al., (2011) who assessed the effect of drought stress wheat & barley and indicated no significant correlation between grain yield and plant height under both stressed and non-stressed conditions. Furthermore, taller plants invest most of it is photo-assimilate in lengthening of it is internodes with low assimilate allocation toward spike. Hence, produced lower yield compared to semi-dwarf cultivars (Flintham et al., 1997). Grain yield was positively correlated with peduncle length at SS only. This was inconsistent with Babaiy et al., (2011) who studied the correlation of yield with yield components in barley and reported no correlation between grain yield and peduncle length. Present results showed positive ($P<0.05$) correlation between grain yield and spike length at each of NS, SS and SE treatments. With regard to the rest of possible correlations between plant height, peduncle length and spike length, statistical analysis showed only three positive ($P<0.05$) correlations, two of them at NS and between peduncle length and each of plant height and spike length. The third one was presented at SE between peduncle length and plant height (Table 3). These findings were consistent with Amiri et al. (2013) who reported a positive and significant correlation between peduncle length with plant height and with spike length at zero- stress conditions.

CONCLOUSION

Results of this study indicated that pre-anthesis water deficit had significant effect on all studied traits (plant height, peduncle length and spike length). Morex was consistently the tallest under no stress (NS), stress at tillering (SS) and stress at stem elongation (SE) whereas, Tadmor has the longest spike. Grain yield was highly correlated with spike length under each of NS, SS and SE treatments. Current study showed high genetic variability among the studied barley genotypes that could be used as a rich genetic resource for breeders to develop newer barley drought tolerant genotypes.

ACKNOWLEDGMENTS

We gratefully acknowledge the Deanship of Scientific Research, Jordan University of Science and Technology, and Deanship of Academic Research, The University of Jordan for their financial support.

Table 1: Mean square of tested barley genotypes and stress treatments on plant height, peduncle length and spike length.

Source of variation	Degree of freedom	Plant height	Peduncle length	Spike Length
Replication	5	43.93 ns	10.72 ns	1.10ns
Genotype	12	1546.72**	176.23**	26.08**
Stress Treatment	2	9554.14**	409.80**	33.06**
Stress Treatment x Genotype	24	103.41**	21.76**	1.02 ns
Error	190	28.57	6.63	0.98
Total	233			

*** is P<0.05 significant, ** P < 0.01 is highly significant, ns= non-significant.**

Table 2. Average of plant height (PH), peduncle length (PL) and spike length (SL) for13 tested barley genotypes under three treatments (NS, SE, and SS).

	PH (cm)				PL (cm)				SL (cm)			
Genotype	**NS**	**SE**	**SS**	**Mean**	**NS**	**SE**	**SS**	**Mean**	**NS**	**SE**	**SS**	**Mean**
Morex	95.4a	72.8a	64.4a	**77.57a**	8.4a	4.1a	-1.2ab	**3.78a**	8.1ab	6.5bc	8.1a	**7.58ab**
Steptoe	79.4b	39.9fg	52.5bc	**58.34c**	-5.7fg	-5.7def	-8.7e	**-6.78g**	5.2d	3.0f	3.7f	**4.06d**
Rum	74.1bc	57.5b	57.3b	**63.65b**	4.2bc	0.0b	**-0.1a**	**1.52b**	7.1bc	5.3e	4.8e	**5.73d**
ER	69.5cd	47.3c-e	45.3d-g	**54.07d-f**	5.4ab	-3.7bc	-3.7b-d	**-0.65c**	8.3ab	6.8a-c	6.6cd	**7.25bc**
Tadmor	69.1cd	49.9cd	48.0c-e	**54.90c-e**	1.8b-d	-4.4c-e	-4.4cd	**-2.57de**	8.8a	7.4a	7.8ab	**7.95a**
Muta'	67.1de	44.6d-f	44.7e-g	**52.15ef**	0.7c-e	-4.3cd	-2.7bc	**-2.09cd**	8.5ab	6.8a-c	7.6ab	**7.60ab**
Yarmok	66.1de	53.4bc	49.2c-e	**56.22cd**	2.7b-d	-3.3c	-3.7b-d	**-1.43cd**	8.3ab	7.2ab	7.2bc	**7.56ab**
Acsad	63.6d-f	46.2de	44.2e-g	**51.35ef**	0.7c-e	-4.3cd	-2.7bc	**-2.09cd**	6.1cd	5.1e	4.9e	**5.37d**
Keel	62.4ef	45.8d-f	51.6b-d	**53.24d-f**	-2.5ef	-6.5ef	-3.3b-d	**-4.11ef**	7.6a-c	6.6bc	7.1bc	**7.12bc**
GP	62.3ef	43.5e-g	45.8d-f	**51.15f**	-4.6fg	-5.2c-f	-5.4d	**-5.00f**	8.1ab	6.3cd	7.3a-c	**7.49ab**
Arta	57.7fg	37.7fg	39.6f-h	**45.02g**	0.2c-e	-4.8c-e	-3.7b-d	**-2.78de**	7.5a-c	6.3cd	6.3d	**6.69c**
MF	55.4g	46.3de	39.4gh	**46.56g**	-7.8g	-6.8f	-10.5e	**-8.42g**	5.3d	5.2e	5.0e	**5.16d**
Ubi	48.5h	32.2h	35.1h	**38.57h**	-4.0fg	-4.1cd	-4.7cd	**-4.26ef**	6.1cd	5.6de	5.1e	**5.60d**
Mean	**67.1a**	**47.4b**	**47.4b**		**-0.002a**	**-3.84b**	**-4.39b**		**7.30a**	**6.15b**	**6.26b**	

NS: no stress SE: stress at stem elongation stage SS: stress at seedling stage
Means followed by the same letter within the column are not significantly different according to LSD test at P≤ 0.05.

Table 3. Correlation coefficients between plant height (PH), peduncle length (PL), a spike length for the 13 barley genotypes evaluated under 3 testing environments (NS, SE, and SS).

NO Stress (NS)			
	PH	**PL**	**SL**
PL	0.62*		
SL	0.25^{ns}	0.63*	
GY	-0.07^{ns}	0.53^{ns}	0.57*
Tillering Stage (SS)			
	PH	**PL**	**SL**
PL	0.47^{ns}		
SL	0.24^{ns}	0.37^{ns}	
GY	0.18^{ns}	0.72**	0.67**
Stem Elongation Stage (SE)			
	PH	**PL**	**SL**
PL	0.71**		
SL	-0.01^{ns}	0.16^{ns}	
GY	0.22^{ns}	0.17^{ns}	0.70**

ns, * and **: not significant and Significantly rank corrected at the 0.05 and 0.01 probability level, respectively

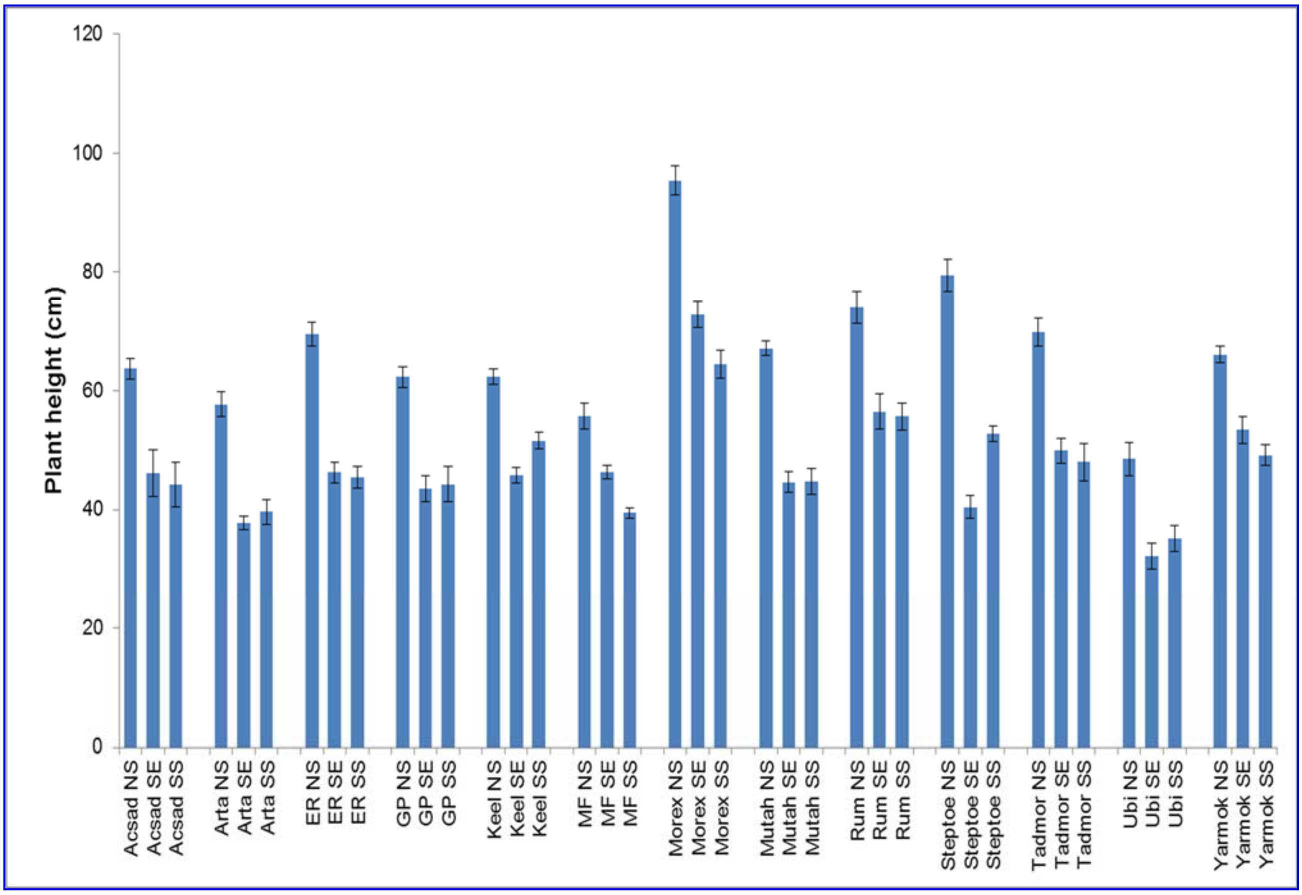

Figure 1. Plant height of 13 tested barley genotypes under three water treatments (NS: no stress; SE: stress at stem elongation stage; SS: at seedling stage). Bars represent standard error.

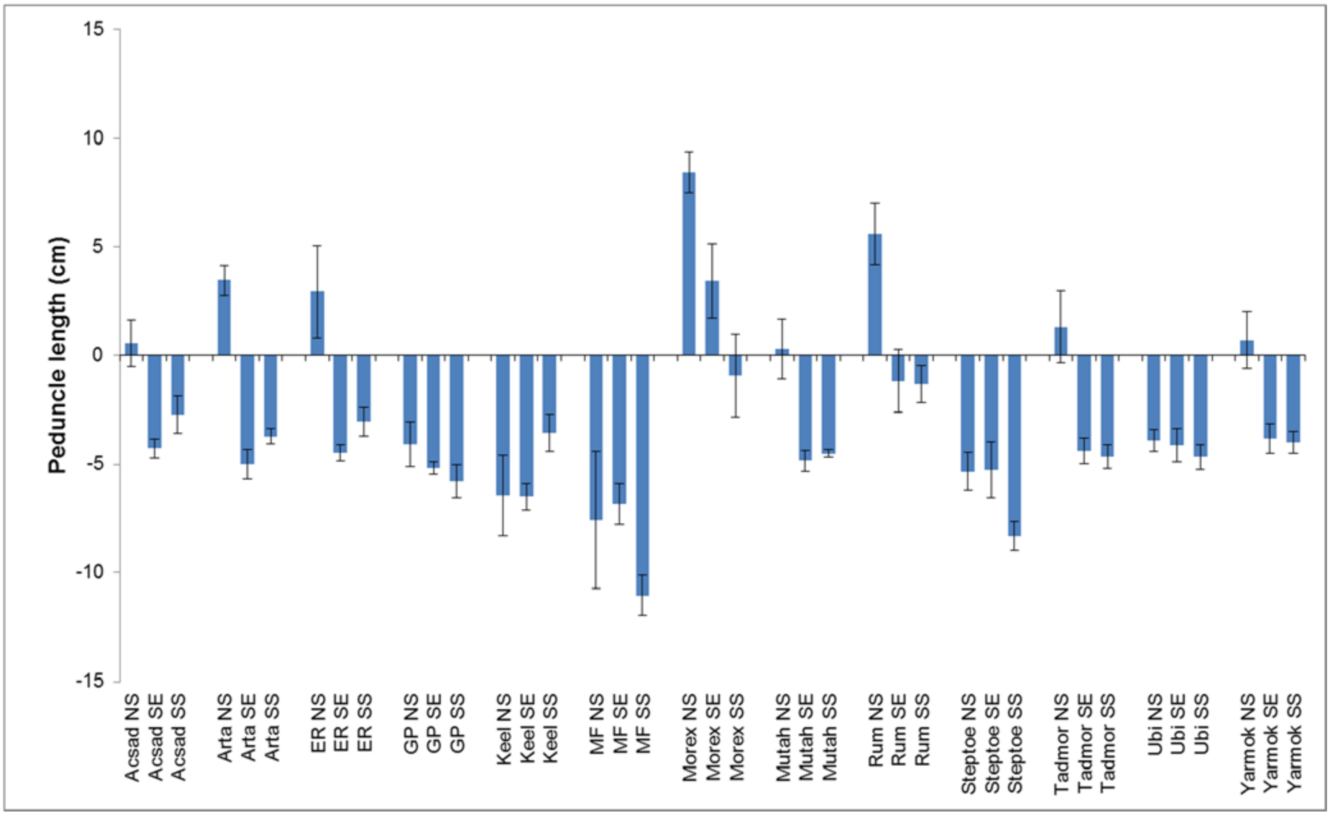

Figure 2. Peduncle length of 13 tested barley genotypes under three water treatments (NS: no stress; SE: stress at stem elongation stage; SS: stress at seedling stage). Bars represent standard error.

REFERENCES

Al-Rawashdeh, Y., Salameh, S. and Al-Nasir, F. 2013. Response of some barley varieties to seeding rates and nitrogen fertilizer levels under rain-fed conditions in south Jordan. ***Damascus University Journal for Agricultural Sciences (DUJAS),*** 29(2):99-115.

Amiri, R., Bahraminejad, S., Jalali, S. 2013. Honarmand Effect of terminal drought stress on grain yield and some morphological traits in 80 bread wheat Genotypes. ***International Journal of Agriculture and Crop Sciences,*** 5 (10): 1145-1153.

Asseng, S., van Herwaarden, AF. 2003. Analysis of the benefits to wheat yield from assimilates stored prior to grain filling in a range of environments. ***Plant Soil,*** 256: 217–229

Babaiy, AH., Aharizad, S., Mohammadi, A., Yarnia, M.(2011. Survey, correlation of yield and yield components in 40 lines barley (*Hordeum vulgare* L.) in region Tabriz. ***Middle-East Journal of Scientific Research,*** 10 (2): 149-152.

Baenziger, PS., McMaster, GS., Wilhelm, WW., Weiss, A., Hays, JC. 2004. Putting genes into genetic coefficients. ***Field Crop Research,*** 90: 133 – 143.

Bingham, IJ., Blake, J., Foulkes, MJ., Spink, J. 2007. Is barley yield in the UK sink limited? I. Post-anthesis radiation interception, radiation use efficiency and source–sink balance. ***Field Crops Research,*** 101:198–211.

Bogale, A., Tesfaye, K., Geleto, T. 2011. Morphological and physiological attributes associated to drought tolerance of Ethiopian durum wheatgenotypes under water deficit. Journal ***of*** Biodiversity ***and*** Environmental Sciences, 1(2):22-36

Budak, N., Baenziger, PS., Eskridge, KM., Baltensperger, D., Moreno-Sevilla, B. 1995. Plant height response of semidwarf and nonsemidwarf wheats to the environment. ***Crop Science,*** 35. 447-451.

Ceccarelli, S., Grando, S. 1996. Drought as a challenge for the plant breeder. ***Plant Growth Regulation,*** 20:149–155.

Ceccarelli, S., Grando, S., Maatougui, M., Michael, M., Slash, M., Haghparast, R., Rahmanian, M., Taheri, A., Al-Yassin, A., Benbelkacem, A., Labdi, M., Mimoun, H., Nachit, M. 2010. Plant breeding and climate changes. ***Journal of Agricultural Science,*** 148:1-11.

Dodig, D., Zoric, M., Jovic, M., Kandic, V., Stanisavljevic, R., Šurlan-Momirovic, G. 2014. Wheat seedlings growth response to water deficiency and how it correlates with adult plant tolerance to drought. ***The Journal of Agricultural Science,*** 153(03):466-480.

Fischer, RA., Turner, NC. 1978. Plant productivity in the arid and semiarid zones. ***Annual Review of Plant Physiol,*** 29:277–317.

Flintham, J.E., A. Borner, AJ., Worland, MD., Gale. 1997. Optimizing wheat grain yield: effects of *Rht* (gibberellin-insensitive) dwarfing genes. ***Journal of Agricultural Science,*** 128: 11-15.

Francia, E,. Tondelli, A., Rizza, F., Badeck, F., Li Destri Nicosia, O., Akar, T., Grando, S., Al-Yassin, A., Benbelkacem, A., Thomas, W., van Eeuwijk, F., Romagosa, I., Stanca, A., Pecchioni, N. 2011. Determinants of barley grain yield in a wide range of Mediterranean environments. ***Field Crops Research,*** 120(1): 169-178.

Horsham, G. 2011. Victorian winter crop summary, Department of Primary Industries/Farm Services/Grains research and Development Corporation. ***Australia***: **pp.** 16-25.

Kapusi, E. 2010. Elimination of selectable marker genes via segregation of uncoupled T-DNAs in populations of doubled haploid barley, Dissertation, **Martin-Luther-University Halle-Wittenberg.**

Mazid, A., Aw-Hassan, A. and Salahieh, H. (2007), Farmer performance criteria for new barley varieties and their diffusion through farmer–to–farmer seed distribution. **International Center for Agricultural Research in Dry Areas, pp: 7.**

Naghaii, V., Asgharipour, MR. 2011. Difference in drought dtress responses of 20 barley genotypes with contrasting drought tolerance during grain filling. ***Advances in Environmental Biology,*** 5(9): 3042-3049.

Najaphy, A., Ashrafi Parchin, R., Farshadfar, E. 2012. Comparison of phenotypic and molecular characterizations of some important wheatcultivars and advanced breeding lines. ***Australian Journal of Crop Science,*** 6(2):326-332

Niari Khamssi, N., Najaphy, A. 2012. Agro-morphological and phenological attributes under irrigated and rain-fed conditions in bread wheat genotypes. ***African Journal of Agriculture Research,*** 7(1):51-57

Rőder, MS., Plaschke, J., Konig, SU., Borner, A., Sorrells, ME., Tanksley, SD., Ganal, MW. 1998. Abundance, variability and chromosomal location of microsatellites in wheat. ***Molecular Genetics and Genomics,*** 246: 327–333.

Robertson, LD., and Stark, JC. 2003. Variety selection, pp. 9 - 14. In: Robertson, L. D., Wesenberg, D, M., Brown, B.D., Burrup, D.E. and Whitmore, J.C. (eds). **Idaho Spring Barley Production Guide**, University of Idaho.

Samarah, N. 2005. Effects of drought stress on growth and yield of barley. ***Agronomy for Sustainable Development,*** 25(1):145-149.

Samarah, N., Alqudah, A., Amayreh, J., McAndrews, G. 2009. The effect of late-terminal drought stress on yield components of four barley cultivars. ***Journal of Agronomy and Crop Science,*** 195(6):427-441.

SAS Institute Inc,. 1996. SAS/STAT User's Guide, version 6, 4th edi. Vol.1 and 2 SAS Institute, Inc., Cary, NC.

Shakhatreh, Y., O.Kafawin, S. Ceccarelli and H. Saoub 2001. "Selection of Barley Lines for Drought Tolerance in Low-Rainfall Areas J. Agronomy &Crop Science 186, 119-127.

Talebi, R., Fayaz, F., Mohammadi Naji, A. 2009. Effective selection criteria for assessing drought stress tolerance in durum wheat (Triticum durum Desf.). ***General and Applied Plant Physiology,*** 35(1-2):64-74.

Villegas, D., Garcýa del Moral, LF., Rharrabti, Y., Martos, V., Royo, C. 2007. Morphological traits above the flag leaf node as indicators of drought susceptibility index in durum wheat. ***Journal of Agronomy and Crop Science,*** 193, 103–116.

von Bothmer, R., Sato, K., Komatsuda, T.,Yasuda, S., Fischbeck, G. 2003 The domestication of cultivated barely. In: von Bothmer R, van Hintum T, Knüpffer H and Sato K (eds) Diversity in barley (*Hordeum vulgare*).Elsevier Science BV, Amsterdam, The Netherlands, pp 53–76.

Waddington, SR., Ransom, JK., Osmanzai, M., Saunders, DA. 1986. Improvement in the yield potential of bread wheat adapted to northwest Mexico. ***Crop Science,*** 26: 698–703.

Wahbi, A., Sinclair, TR. 2005. Simulation analysis of relative yield advantage of barley and wheat in an eastern Mediterranean climate. **Field Crop Research,** 91: 287 – 296.

Wang, J., Yang, J., McNei, DL., Zhou, M. 2010. Identification and molecular mapping of a dwarfing gene in barley (Hordeum vulgare L.) and its correlation with other agronomic traits. ***Euphytica,*** 175:331–342

Worland, AJ., Korzun, V., Roder, MS., Ganal, MW., Law, CN. 1998. Genetic analysis of the dwarfing gene (Rht8) in wheat. Part II. The distribution and adaptive significance of allelic variants at the Rht8 locus of wheat as revealed by microsatellite screening. ***Theoretical and Applied Genetic***, 96: 1110-1120.

Zare, M., Azizi, MH., Bazrafshan, F.2011. Effect of drought stress on some agronomic traits in ten barley (Hordeum vulgar) cultivars. ***Journal of Applied Science & Engineering Technology,*** 1(3):57-62

Zadoks, J.C., Chang, T.T., Konzak, C.F. 1974. A Decimal Code for the Growth Stages of Cereals. Weed Research 1974 14:415-421

Zhang, X., Yang, S., Zhou, Y., He, Z., Xia, X. 2006. Distribution of the Rht-B1b, Rht-D1b and Rht8 reduced height genes in autumn-sown Chinese wheats detected by molecular markers. ***Euphytica,*** 152: 109-116.

تأثير نقص الماء خلال فترة ما قبل الأزهار على طول النبات، وطول السويقة وطول السنبلة في 13 صنف من بنات الشعير (*Hordeum vulgare* L.)

زكريا العجلوني[1]✉، عبداللطيف الغزاوي[2]، عايد العبداللات[3,4]، جمال عياد[3]، جمال أبو العينين[3]،

نسرين القرعان[5]، ستيف بيتر بينزيجر[6]

ملخص

أجريت هذة الدراسه على 13 صنفا من نبات الشعير (*Hordeum vulgare* L.). وزرعت هذة الاصناف باستخدام 6 مكرارات وزعت عشوائيا على كل قطاع لدراسة تأثير العجز المائي قبل الأزهار على طول النبات، طول السويقة وطول السنبلة. وقد لوحظت فروق معنوية ذات دلالة إحصائية بين الأنماط الجينية لجميع الصفات المدروسة. وكان التباين الوراثي أعلى من التباين الناتج عن التفاعل بين الطراز الجيني والبيئه (GEI). بينت نتائج الدراسة وجود تأثير مختلف ومتنوع لنقص الماء في مرحلة ما قبل الأزهار. بحيث كان تأثر الاصناف مختلافا بالنسبة لطول النبات، طول السويقة وطول السنبلة. في حالة توفر الماء كان متوسط طول النبات (67 سم) لجميع الأصناف وهو أعلى بكثير من متوسط طول النباتات في حاله نقص الماء. وكان الصنف Morex أطول صنف وأطول سويقة بالمقارنة مع جميع الأصناف (77.6 سم و 3.78 سم، على التوالي). في حين الصنف Ubi هو الأقصر طولا، وكان الصنف MF أقصر سويقة. في حين كان الصنف Tadmor أطول سنبلة (7.95 سم) بينما كان الصنف Steptoe يحتوي على أقصر سنبلة. كما بينت هذة الدراسة بأنه يوجد تأثير أيجابي ومعنوي بين طول السنبلة وكمية الأنتاج في جميع المعاملات المدروسة (NS، SS و SE) مما يدل على أهمية هذة الصفة لزيادة الإنتاج في نبات الشعير بشكل غير مباشر.

الكلمات الدالة: الجفاف، الأردن، استطالة الساق، الانتاج، انتخاب.

[1] قسم الإنتاج النباتي، كلية الزراعة، جامعة العلوم والتكنولوجيا الأردنية، أربد– الأردن.
ziajlouni@just.edu.jo

[2] قسم الأحياء، كلية العلوم، الجامعة الهاشمية، الزرقاء–الأردن.

[3] قسم البستنة والمحاصيل، كلية الزراعة، الجامعة الأردنية، عمان -الأردن.

[4] المركز الدولي للأبحاث الزراعية في المناطق الجافة (ايكاردا). عمان– الأردن.

[5] قسم العلوم الحياتية ، كلية العلوم ، جامعة العلوم والتكنولوجيا الأردنية، اربد– الأردن.

[6] قسم المحاصيل والبستنة، جامعة نبراسكا الأمريكية، نبراسكا– أمريكا.

تاريخ استلام البحث 2016/1/26 وتاريخ قبوله 2016/5/26.