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The Effect of Spike Row Type on the Grain Yield and Grain Filling Parameters in Barley (*Hordeum vulgare* L.) Genotypes under Semi-arid Conditions

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ABSTRACT

Background: Barley (*Hordeum vulgare* L.) is one of the more important cultivated crops in the Mediterranean region, where drought and high temperatures during the grain filling stage are the main abiotic stresses limiting its production. The aim of this study is to evaluate the effects of the spike type on the grain yield, thousand kernels weight and some grain filling parameters.

Methods: The present study was conducted on the experimental site of station ITGC in Setif, Algeria, eight Barley genotypes were tested during two cropping seasons (2017/2018 and 2018/2019) in a randomized block design with 3 replications.

Result: The results proved significant effect of genotypes and spike types on the grain filling parameters, but no significant effect of spike type on the thousand kernels weight during the both cropping seasons. In addition, the spike type registered significant effect just during the second cropping season. Among the genotypes with 6 rows spike type the local genotype Fouarra have high grain yield (97.79 Q/ha) with a deviation of 37.57% from the total mean of the genotypes with 6 row spike type. Many studies proved that in 6-row barleys, the magnitude of contribution of grain number in grain yield was higher than contribution of grain weight. The grain growth of genotypes studied follows a sigmoid curve, during the first season (2017-2018) the duration of grain filling ranged between 24 days for Saida 183 and 28 days for Rihane 03, for the group of genotypes with 6 rows. In addition, the duration of grain filling for the 2 row genotypes varied from 24 days for G4 to 28 days for genotype G2. During the second season (2018-2019) and for the genotypes with 6 rows, the duration of the grain filling varied from 21 days for the Saida 183 and 26 days for the genotype Fouarra, for the genotypes with 2 rows the duration of grain filling ranged from 21 days for the genotype G2 to 26 days for the genotype G3. The correlation analysis between the grain filling parameters, GY and TKW demonstrate a significant and positive correlation between TKW and MGW and GFR (r = 0.82* and r = 0.84*, respectively). Overall, the genotype variation in grain filling velocity and duration was responsible for the difference in grain yield and the improvement in grain yield was achieved by the increasing in velocity or duration of grain filling.

Key words: Barley, Grain filling, Spike type, Semi-arid, TKW.

INTRODUCTION

Barley (*Hordeum vulgare* L.), is an annual monocotyledonous plant. Barley genotypes are classified according to ear structure as either 2-row or 6-row. Barley has been used as animal fodder, as a source of fermentable material for beer and certain distilled beverages and as a compound of various health foods. The growing demand for barley by the food industry is mainly because of its health-promoting beta-glucan, acetylcholine, lysine, thiamine and riboflavin contents and the easy digestibility (Marwat *et al.* 2012). The understanding of the potential grain yields of 2 and 6 row and of the ways in which their yield is obtained may help the plant breeder. Grain filling, the final process associated with yield performance, is a crucial determinant of grain yield in cereal crops. Moreover, abiotic stress (drought and heat) during grain filling stage of the barley growth cycle limit its productivity. Many studies reported a significant effect of terminal drought conditions on barley yield ranging from 27 to 41% (Przulj and Momcilovic, 2012). Several authors reported a significant effect of grain filling rate and grain filling duration on final individual grain weight in barley genotypes. Grain yield and its components are the major selection criteria for evaluating drought tolerance under field conditions. Samarah *et al.* (2009), suggested that under water and heat stress conditions the six-rowed genotypes achieved better yield than two-rowed genotypes. The six-rowed barley proved to be more stable behavior to environmental variations, but the yield of two-rowed barley proved to be more responsive inter-annual variation. The aim of this study is to compare the comportment of two and six rowed barley genotypes based on the grain filling parameters in relationship with grain yield and thousand kernel weight.

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MATERIALS AND METHODS

Plant material and experiment designs

Eight Barley genotypes (*Hordeum vulgare* L.) were planted during two cropping seasons (2017-2019), in randomized block design with three replicates at the experimental fields of ITGC, Setif, Algeria (5°20′E, 36°8′N, 958 m above sea level). Plots were 5 m × 6 rows with 0.20 m row spacing and sowing density was adjusted to 250 g m^{-2}.

Agronomical and grain filling parameters

The grain yield and thousand kernel weight were estimated at harvest. The grain filling parameters are presented in Table 1.

Statistical analysis

To evaluate significant differences between genotypes, the one-way analysis of variance (ANOVA) was performed. Fisher's LSD multiple range test was employed for the mean comparisons.

RESULTS AND DISCUSSION

Grain yield and TKW

The genotypes effect was significant for the grain yield and thousand-kernel weight during the both cropping seasons (Table 2). For the first cropping season, the values of grain yield are varied between 43.99 Q/ha for the local genotype Rihane 03 to 74.4 Q/ha for the local genotype Fouarra and during the second cropping season, the values of grain yield are varied between 48.02 Q/ha for the introduce genotype G4 to 97.79 Q/ha for the local genotype Fouarra. Based on the results of the two cropping seasons, the test of means comparison showed that the genotype with highest grain yield is the local genotype Fouarra. Among all introduce genotypes the genotype G1 have the good grain yield during the first and second cropping season (68.39 and 65.69 Q/ha, respectively). As shown in Table 2, the highest TKW during the first and second cropping season is registered by the local genotype Saida 183 (55.91 and 44.88 g, respectively). Over all, the introduce genotype (2 rows) G1 has the highest TKW during the two-cropping season among all introduce genotypes tested. The ANOVA results of the spike type effects showed a significant effect on the grain yield just during the second cropping season, the mean grain yield in the 6 row (71.08 Q/ha) better than the 2 row (55.03 Q/ha). Among the genotypes with 6 rows spike type the local genotype Fouarra have high grain yield (97.79 Q/ha) with a deviation of 37.57% from the total mean of the genotypes with 6 row spike type. Many studies proved that in 6-row barleys, the magnitude of contribution of grain number in grain yield was higher than contribution of grain weight (Vaezi *et al*. 2010; Bavi *et al*. 2011; Mirosavljević *et al*. 2018).

Grain filling parameters

The grain growth of genotypes studied follows a sigmoid curve similar to that described by Triboi (1990) and Guendouz and Maamori (2012) (Fig 1). As described by Yoshida (1981) the grain filling, is the final process associated with yield performance, is a crucial determinant of grain yield in cereal crops; grain growth of field crops is initially slow, enters a linear phase where the growth rate is fast and then slows down toward maturity. During the first season (2017-2018) the duration of grain filling ranged between 24 days for Saida 183 and 28 days for Rihane 03, for the group of genotypes with 6 rows. In addition, the duration of grain filling for the 2 row genotypes varied from 24 days for G4 to 28 days for genotype G2. During the second season (2018-2019) and for the genotypes with 6 rows, the duration of the grain filling varied from 21 days for the Saida 183 and 26 days for the genotype Fouarra, for the genotypes with 2 rows the duration of grain filling ranged from 21 days for the genotype G2 to 26 days for the genotype G3. Under environmental stress, e.g. high temperatures after anthesis, grain yield will be reduced due to a decline of single grain weight (Porter and Gawith, 1999), over the range of 12 to 26°C increase in mean temperature during grain filling, grain weight is reduced at a rate of 4 to 8% / °C (Wardlaw *et al*. 1980). In addition, water stress during grain filling affect directly the grain weight is, however, reduced (Hochman, 1982) due to a shortening of the grain filling period resulting from accelerated senescence of flag leaf. As shown in Table 2, all grain filling parameters are affected by the genotypes and spike type during the two cropping seasons. Based on the ANOVA analysis of the genotypes effects, the introduce genotype G2 with 2 row spike type has the highest MGW and GFR among all genotypes tested. In addition, the ANOVA analysis based on the spike type showed a significant difference between the 2 and 6 row and the highest values of MGW, GFR and MFR is registered by the genotypes with 2 row (the introduce genotypes G1 and G2).

Table 1: List of calculated grain filling parameters.

Grain filling parameters	Acronym	Measurement units	Equations
The maximum grain weight	MGW	mg	Estimated on the basis of single grain weight at different sampling points
The grain filling rate	GFR	mg 100 GDD day^{-1}	GFR= final grain dry weight/ GFD
The maximum grain filling rate	MFR	mg 100 GDD day^{-1}	Estimated on the basis of AFI for each genotype
The grain filling duration	GFD	°C	Accumulated GDD from anthesis
The absolute intensityof grain filling rate	AFI	mg day^{-1}	AFI = W2 - W1/T2 - T1
Growing degree days summationof daily degree days (Tn)	GDD	°C	Tn = [(Tmax + Tmin)/2 - Tb]

Tn = Daily degree day, Tmax = Maximum daily temperature, Tmin = Minimum daily temperature, Tb = Base temperature (0°C); W1 and W2= Dry weights of sample at time T1 and T2, respectively.

Table 2: Grain filling parameters, grain yield and thousand kernel weight.

Cropping season	Row type	Genotypes	MGW	GFR	MFR	GFD	GY	TKW
2017 - 2018								
	2 Row	G1	52.07 (bc)	0.121 (bc)	3.01 (a)	352.2 (b)	68.39 (a)	50.29 (bc)
		G2	56.07 (a)	0.131 (a)	3.29 (ab)	427.6 (a)	57.08 (b)	52.49 (b)
		G3	53.4 (ab)	0.124 (bc)	2.65 (bc)	402.46 (ab)	56.77 (b)	50.09 (bcd)
		G4	53.26 (b)	0.124 (b)	2.66 (bc)	377.33 (ab)	46.72 (c)	48.64 (cd)
	6 Row	Fouarra	47.93 (d)	0.112 (d)	2.22 (c)	427.6 (a)	74.40 (a)	47.53 (d)
		Saida 183	53.03 (b)	0.124 (b)	2.83 (ab)	427.6 (a)	52.36 (bc)	55.91 (a)
		Tichedrett	49.83 (cd)	0.116 (cd)	2.83 (ab)	402.46 (ab)	57.44 (b)	49.89 (bcd)
		Rihane 03	43.51 (e)	0.101 (e)	2.44 (c)	402.46 (ab)	43.99 (c)	41.01 (e)
	Genotype effects		***	***	***	***	***	***
	LSD5%		2.68	0.0062	0.567	56.71	9.01	2.71
	Row effects		***	***	***	ns	ns	ns
	Mean 2 Row		53.7 (a)	0.125 (a)	2.90 (a)	389.9 (a)	57.24 (a)	50.38 (a)
	Mean 6 Row		48.58 (b)	0.113 (b)	2.58 (b)	415.03 (a)	57.05 (a)	48.59 (a)
	LSD5%		2.61	0.0061	0.321	29.4	9.48	3.6
2018 - 2019								
	2 Row	G1	40.48 (b)	0.109 (b)	4.00 (a)	280.8 (c)	65.69 (bc)	38.9 (bc)
		G2	46.07 (a)	0.125 (a)	3.48 (ab)	280.8 (c)	56.24 (bc)	42.71 (ab)
		G3	39.61 (b)	0.107 (b)	2.71 (cd)	322.6 (b)	50.17 (c)	38.81 (bc)
		G4	36.08 (cd)	0.098 (cd)	2.92 (bc)	270.83 (c)	48.02 (c)	37.05 (cd)
	6 Row	Fouarra	27.15 (e)	0.073 (e)	2.08 (d)	337.8 (b)	97.79 (a)	33.42 (d)
		Saida 183	37.18 (c)	0.100 (c)	2.70 (cd)	337.8 (b)	62.73 (bc)	44.88 (a)
		Tichedrett	35.11 (d)	0.095 (d)	2.35 (cd)	368.2 (a)	50.61 (c)	41.75 (ab)
		Rihane 03	34.50 (d)	0.093 (e)	3.04 (bc)	270.83 (c)	73.20 (b)	34.92 (cd)
	Genotype effects		***	***	***	***	***	***
	LSD5%		1.71	0.0046	0.708	27.24	18,75	4.46
	Row effects		***	***	**	**	*	ns
	Mean 2 Row		40.56 (a)	0.110 (a)	3.28 (a)	288.7 (b)	55.03 (b)	39.37 (a)
	Mean 6 Row		33.48 (b)	0.090 (b)	2.54 (b)	328.65 (a)	71.08 (a)	38.74 (a)
	LSD5%		3.33	0.009	0.486	27.94	13.85	3.69

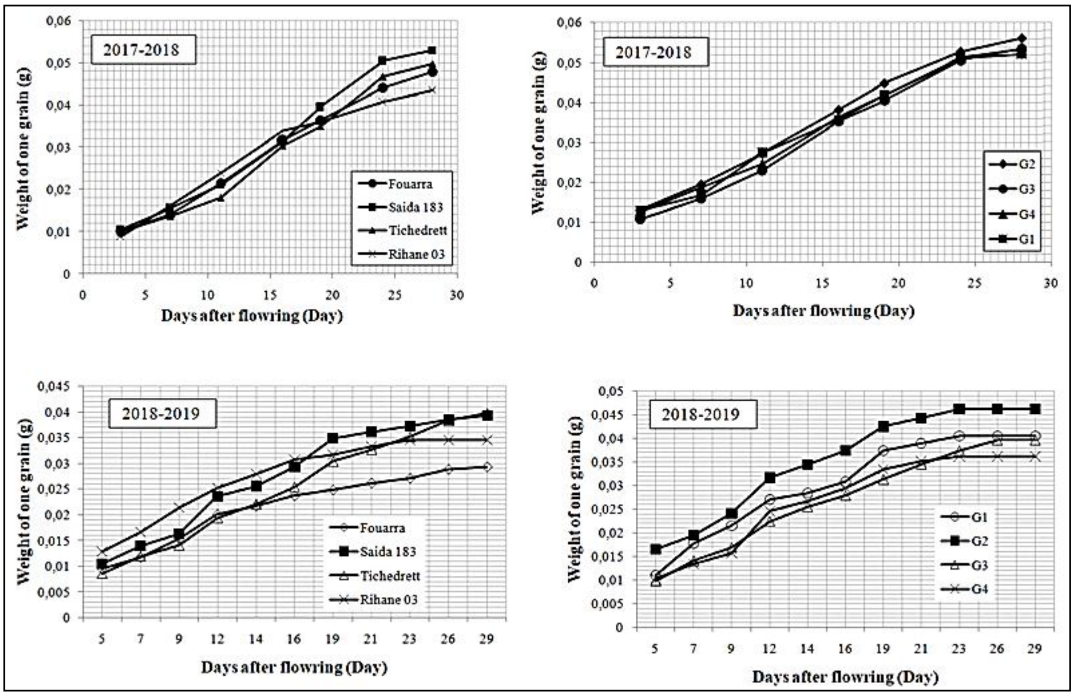

Fig 1: Evolution of the grain filling (g) of the genotypes tested during the both growing seasons.

The results demonstrate that the group of the genotypes with 2 rows has mean velocity of grain filling more than the group of genotypes with 6 rows, these results proved that the genotypes with 2 rows more sensitive to water stress in comparison with the genotypes with 6 rows. A long duration of grain filling is often indicator of photosynthetic activity optimum, but a high velocity of filling is indicative effects of water stress (Sofield *et al*. 1977). The correlation analysis between the grain filling parameters, GY and TKW demonstrate a significant and positive correlation between TKW and MGW and GFR (r=0.82* and r=0.84*, respectively) just during the first cropping season; this results in agreement with the results of the study of Samarah *et al*. (2009) and González *et al*. (2007), which registered a significant correlation of GY with MGW, TKW, MFR and GFR was also positive but lower. These results suggest that the genotypes with high values in MGW and GFR had highest TKW. The GFD and GFR are related negatively but weakly (r = -0.40), *i.e.* a lower speed of grain filling is not necessarily offset by an increase in duration of filling. While, (Wang *et al*. 2009; Jocković *et al*. 2014) found a strong negative correlation between these two components. This a strong correlation indicate compensation between these two variables, but Triboi (1990) found that this compensation phenomenon no effect on the final dry weight of grain.

CONCLUSION

The genotypes effect was significant for the grain yield and thousand-kernel weight during the both cropping seasons. Based on the rustles of the two cropping seasons, the test of means comparison showed that the genotype with highest grain yield is the local genotype Fouarra with 6 rows. Among all introduce genotypes (2 rows group) the genotype G1 has the good grain yield during the first and second cropping season. In addition, the highest TKW during the first and second cropping season is registered by the local genotype Saida 183 (6 rows). Over all, the introduce genotype (2 rows) G1 has the highest TKW during the two cropping season among all introduce genotypes tested. The grain growth of genotypes studied follows a sigmoid curve. The ANOVA analysis of the genotypes effects, proved that the introduce genotype G2 with 2 row spike type has the highest MGW and GFR among all genotypes tested. In addition, the ANOVA analysis based on the spike type showed a significant difference between the 2 and 6 row and the highest values of MGW, GFR and MFR is registered by the genotypes with 2 row (the introduce genotypes G1 and G2). The genotype variation in grain filling velocity and duration was responsible for the difference in grain yield and the improvement in grain yield was achieved by the increasing in velocity or duration of grain filling.

REFERENCES

Bavi, V., Vaezi, B., Abdipour, M., Reza, J.K.M. and Roustai, M. (2011). Screening of tolerant spring barleys for terminal heat stress: Different importance of yield components in barleys with different row type. International Journal of Plant Breeding and Genetics. 5(3): 175-193.

González, A., Martín, I., Ayerbe, L. (2007). Response of barley genotypes to terminal soil moisture stress: Phenology, growth and yield. Australian Journal of Agricultural Research. 58: 29-37.

Guendouz A., Maamari, K. (2012). Grain-filling, chlorophyll content in relation with grain yield component of durum wheat in a Mediterranean environment. African Crop Science Journal. 20(1): 31-37.

Hochman, Z.V.I. (1982). Effect of water stress with phasic development on yield of wheat grown in a semi-arid environment. Field Crop Research. 5: 55-67.

Jocković, B., Mladenov, N., Hristov, N., Aćin, V., Djalović, I. (2014). Interrelationship of grain filling rate and other traits that affect the yield of wheat (*Triticum aestivum* L.). Romanian Agricultural Research. 31: 81-87.

Marwat, S.K., Hashimi, M., Usman Khan, K., Aslam Khan, M., Shoaib, M. and Rehman, F. (2012). Barley (*Hordeum vulgare* L.) a prophetic food mentioned in ahadith and its ethnobotanical importance. American-Eurasian Journal of Agricultural and Environmental Sciences. 12: 835-841.

Mirosavljević, M., Momčilović, V., Denčić, S., Mikić, S., Trkulja, D. and Pržulj, N. (2018). Grain number and grain weight as determinants of triticale, wheat, two-rowed and six-rowed barley yield in the Pannonian environment. Spanish Journal of Agricultural Research. 16(3): e0903.

Porter, J.R. and Gawith, M. (1999). Temperature and the growth and development of wheat: a review. European Journal of Agronomy. 10: 23-36.

Pržulj, N. and Momcilovic, V. (2012). Spring barley performances in the Pannonian zone. Genetika. 44(3): 499-512.

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

Sofield, I., Evans, L.T., Cook, M.G., Wardlaw, I.F. (1977). Factors influencing the rate and duration of grain filling in wheat. Australian Journal of Plant Physiology. 4 : 785-797.

Triboi, E. (1990). Modelé d'élaboration du poids du grain chez le blé tendre (*Triticum aestivum*) en thell. Agronomie. 1: 191-200.

Vaezi, B., Bavei, V., Shiran, B. and Moghadam, N. R. (2010). Different contributions of yield component to grain yield in two and six row barley genotypes under terminal heat stress. International Journal of Applied Agricultural Research. 5(3): 385-400.

Wang, R.X., Hai, L., Zhang, X.Y., You, G.Y., Yan, C.S., Xiao, S.H. (2009). QTL mapping for grain filling rate and yield-related traits in RILs of the Chinese winter wheat population Heshangmai × Yu8679. Theoretical and Applied Genetics. 118: 313-325.

Wardlaw, I.F., Sofield, I. and Cartwright, P.M. (1980). Factors limiting the rate of dry matter accumulation in the grain of wheat grown at high temperature. Australian Journal of Plant Physiology. 7: 87-400.

Yoshida, S. (1981). Fundamentals of Rice Crop Science. International Rice Research Institute, Los Banos, Philippines. pp. 59-60.