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Effect of Irrigation Regimes on Grain Growth Indices of Three Winter Wheat (*Triticum aestivum* L.) Cultivars Under the Iranian Conditions

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Abstract: An experiment was conducted during 2004-2006 at the Agricultural Research Station, Islamic Azad University, Khorasgan Branch, Isfahan, Iran. The purpose of this study is to study the effect of deficit irrigation regimes on the grain growth rate and the effective grain filling period of the bread wheat (*Triticum aestivum* L.) cultivars. A split plot layout arranged in randomized complete block design with four replications was used. Irrigation regimes (irrigation after 70 mm (I_1), 90 mm (I_2) and 110 mm (I_3) cumulative evaporation from class A evaporation pan) were considered as the main plot and three wheat cultivars (Mahdavy, Ghods and Roshan-Backcross) as subplots. The I_1 and I_2 did not differ significantly for grain growth rate (GGR) and effective grain filling period (EGFP). Delay in irrigation from the I_2 to the I_3 caused significant reduction in grain growth rate and effective grain filling period. Trend of changes in grain weight was similar in the I_1 and the I_2. In all samplings, delay in irrigation from the I_2 to the I_3 reduced grain weight. Cultivars differed significantly in respect to grain growth. The effect of grain growth rate on 1000-grain weight was more pronounced than effective grain filling period. Obtained results indicate that irrigation after 90 mm cumulative evaporation from class (A) evaporation pan might be suitable for the grain weight of winter wheat under similar the conditions to this experiment where irrigation water during grain filling period is not abundant.

Key words: Grain growth rate, effective grain filling period, 1000- grain weight, wheat

INTRODUCTION

In the semi arid climatic region of Iran, rainfall decrease and evaporation increase in the spring, when wheat enters the grain-filling stage (Naderi *et al*., 2000). Consequently, wheat crops often experience after deficits during grain filling, thereby limiting grain yield (Kobata *et al*., 1992).

A thorough understanding of the grain filling process may be helpful in attempts to breed for increased yield. After seed number has been determined, wheat grain yields become proportional to grain weight, which is a function of the rate and duration of grain filing (Bruckner and Frohberg, 1987). In most cases, rate of grain filing was more important in contribution to higher grain yield than grain filling period (Gebeyehou *et al*., 1982; Darroch and Baker, 1990; Naderi *et al*., 2000). This section is of higher importance during moisture tension condition circumstance within which the filling grain period is reduced. Hossainpoor *et al*. (2003) reported a high correlation between grain weight and its growth speed. There was no specific correlation between the seed grain weight and the filling grain period length. They suggested that the simultaneous selection for the higher grain weight in areas through which the period of grain filling is accompanied by moisture tension would be possible and through the growth speed of the higher grain and without increase in the length of the filling period would be possible. Naderi *et al*. (2000) reported a high correlation between the grain weight and the speed of the grain growth in tension condition. They also stated that the speed of the grain filling had more effect on the grain weight compared with the length of the grain filling period.

The allocation of irrigation water to other more economical products such as summer plants will worth

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considering should we notice the lack of rainfall and limitation of irrigation water in Isfahan Province. In this case both the access to the reduction threshold level of consumption irrigation water to hinder the waste of water supplies and obtaining an optimum grain weight in water limited conditions would be inevitable (Salemi and Afyuni, 2005). Since, there no sufficient investigations about the response of grain weight of wheat genotypes to various limited irrigations regimes under Isfahan circumstances (Salemi and Afyuni, 2005). The aim of this study is to evaluate the effects of various limited irrigation regimes on grain growth rate, effective grain filling period and the effect of these components on grain weight of three winter wheat cultivars under the condition of Isfahan, Iran.

MATERIALS AND METHODS

The experiments were carried out under field conditions at the Agricultural Research Station, Islamic Azad University, Khorasgan Branch, Isfahan, Iran with longitude 51°48′ N and latitude 32°40′ E during 2004-2006. The region is arid with mean annual rainfall of 110 mm. The soil of the field from 0 to 40 cm below the surface was a sandy loam texture. Treatments were arranged as a split plot design in randomized complete block design (RCBD) with four replications. Irrigation treatments were applied from the elongation phase to ripening and were considered as the main plots, it consists irrigation after 70 (I_1), 90 (I_2) and 110 (I_3) mm cumulative evaporation from class (A) evaporation pan. Prior to each irrigation, the soil moisture percent down to the depth of the root was estimated and then the water required for irrigation was entered to the main plots through Parshall flume (Salemi and Afyuni, 2005). Winter wheat cultivars were allocated as sub plots. Used experimental materials are three winter wheat cultivars consists Mahdavy, Ghods and Roshan-backcross. The evaporation value was determined daily. Sowing was done in the first week of November that is the recommended time for wheat in this region. The planting rate was 80 kg m^{-2} with an inter-row space of 20 cm (Salemi and Afyuni, 2005). Two growing season were calculated. The applied fertilizers were 120 kg ha^{-1} ammonium phosphate before planting and 100 kg ha^{-1} nitrogen in two half stages before and half after planting. Ear samples were taken from 0.1 m^{-2} (75 ears per sampling) of all sub plots with 7 days intervals, starting at anthesis (at Zadox stage 6) and oven dried at 65°C for 48 h to determine grain weight.

The initial and the terminate stages (Zadox stages 7-9) of the grain growth rate and the gradient of the regression line as the grain growth rate by using the linear regression method and the Eq. 1 was determined and estimated (Gebeyehou *et al.*, 1982):

$$\text{GGR} = \frac{W_2 - W_1}{t_2 - t_1} \tag{1}$$

where, W_1 and W_2 are the estimated grain weights at times t_1 and t_2.

Considering the ultimate grain weight during the filling period the effective grain filling period (EGFP) was estimated through the following equation relation (Kafi *et al.*, 2001):

$$\text{EGFP} = \frac{\text{Maximum grain weight}}{\text{Grain growth rate}}$$

Statistical analysis was performed using the MINITAB statistical software. Duncan multiple range test was used to determine significant differences of means at the 5% level and figures were drawn using by Microsoft Excel software.

RESULTS AND DISCUSSION

The GW (grain weight): The GW in the irrigation after 90 mm treatment (I_2), in all samples was non-significantly less than the I_1 but significantly more than the I_3 (Fig. 1), so that the I_1 and the I_2 had non-significant differences on GW at the ripening but the difference among them with regard to the I_3 was much and significant (Table 1). The GW reduction after the maximum approach can come about due to abscission of the older leaves and miss of its photosynthesis capacity (Kobata *et al.*, 1992). Within the I_3, the GW reduction process was more sever than that of the I_1 and the I_2 from the maximum occurrence to the economical ripening (Fig. 1). The more senescence of leaves under water deficit stress circumstances can be the cause for the much reduction of the GW in the I_3 (Ali *et al.*, 1999). These outcomes along with reports by

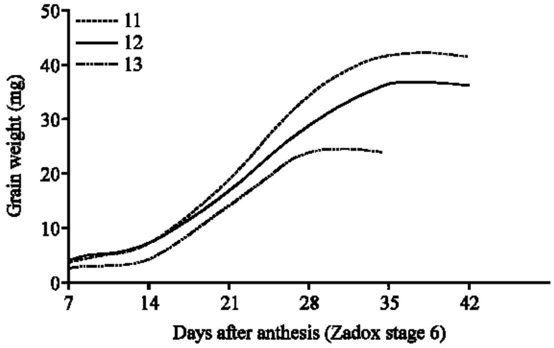

Fig. 1: Variation in the GW in the irrigation regimes

Table 1: Comparison of the irrigation regime means and wheat cultivars growth indices [a]

Experimental factor	GGR (mg g^{-1}grain weight day^{-1})	EGFP (day)	1000-grain weight (g)	LAI (mean)
Irrigation regimes				
70 mm evaporation	1.48a	30.2a	38.35a	2.63a
90 mm evaporation	1.40a	29.8a	36.20a	2.36a
110 mm evaporation	1.12b	24.3b	25.71b	1.57b
Genotypes				
Roshan-backcross	1.43a	28.6a	36.01a	2.33a
Ghods	1.20b	27.5a	30.06b	2.10a
Mahdavy	1.37ab	28.2a	34.22a	2.13a

a: All means followed by the same letter(s) in column are not significantly different at the 5% probability level

Timpa *et al.* (1986) and Bajii *et al.* (2001) regarding of the GW reduction in stress circumstances are totally convergent. The changes in the GW (Table 1) were more similar to the LAI (Table 1). We can conclude that the LAI will be decreased by increasing irrigation intervals (Table 1) and that the GW can be decreased by reduction in photosynthetic capacity (Table 1). Genotypes had significant difference in the GW at the economical ripening. Roshan-Backcross and Ghods had highest and lowest the GW, respectively (Table 1). These genotypes had highest and lowest the LAI, (Table 1) lead to highest and lowest photosynthetic capacity, respectively.

The GGR (grain growth rate): The GGR in I_3 had been significantly lower than I_1 and I_2 treatments (Table 1). But no significant differences between I_1 and I_2 treatments (Table 1). The moisture tension has probably reduced the canopy photosynthesis through the reduction of leaf surface and reduction of stomata conductivity and has indirectly lead to the reduction of the grain growth speed (Kafi *et al*., 2001).

Cultivars had significant effects on GGR (Table 1). Roshan-Backcross and Ghods had the highest and lowest GGR, respectively (Table 1). However, these cultivars had highest and lowest LAI (Table 1) lead to highest and lowest photosynthetic capacity, respectively. Darroch and Baker (1990) reported non-significant differences between wheat cultivars for grain growth rate.

The EGFP (effective grain filling period): The EGFP in I_3 had been significantly lower than I_1 and I_2 treatments (Table 1). However, there were no significant effects between I_1 and I_2 treatments on the measured trait (Table 1). Apparently, the moisture tension during the grain-filling period and through the quick leave senescence has led to the shortening of the grain-filling period length (Kafi *et al*., 2001). Cultivars had no significant difference in the EGFP at the ripening. However, Roshan-Backcross and Ghods had the highest and the lowest the EGFP, respectively (Table 1).

A positive and significant correlation existed between the speed of the grain growth and the 1000-grain weight ($r = 0.78^{**}$). It is estimated that with an increase between the two irrigations, the speed of the grain growth had reduced harmonically (Table 1) and has led to a reduction in 1000-grain weight (Table 1). On the other hand, the existence of a significant difference in the mean of the grain growth speed of the figures (Table 1) caused that the figures have a significant difference in the 1000-grain weight. Therefore, the Roshan-backcross and Ghods cultivars which had the highest and lowest means of the grain growth rate, ranked the same for 1000-grain weight respectively (Table 1). The above results were in accord with the statements reported by Naderi *et al.* (2000), Gebeyehou *et al.* (1982) and Darroch and Baker (1990) on the basis of convergence between the 1000-grain weight and the rate of grain growth within the convergent wheat cultivars. However, the correlation between the effective grain filling period and the 1000-grain weight was positive but not significant ($r = 0.46^{ns}$). We can conclude that the effective grain filling period has declined harmonically with an increase within the two irrigation intervals (Table 1).

Also Bruckner and Frohberg (1987) reported lack of correlation between the 1000-grain weight and the grain filling period. Darroch and Baker (1990) and Naderi *et al.* (2000) stated that the grain growth speed compared with the grain filling period had much more effect on 1000-grain weight of the wheat cultivars which is in accord whit the results of this investigation.

Nakagami *et al.* (2004) and Salemi and Afyuni (2005) reported a non-significant difference in the grain weight during the full irrigation and with 80% field capacity due to the insufficiency of severe water stress, a better-developed root system and maintaining the high leaf nitrogen content in stress treatment. There were no significant differences between the I_1 and the I_2 in the GGR and the EGFP. This reaction caused no significantly differences on grain weight for I_1 and I_2 treatments (Table 1).

In conclusion, irrigation after 70 and 90 mm cumulative evaporation did not differ significantly for grain growth indices grain weight. Irrigation after 110 mm cumulative evaporation significantly reduced grain growth indices and grain weight. In present study, wheat might be irrigated after 90 mm cumulative pan evaporation to save 22% irrigation water under conditions similar to this experiment.

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