



## RESEARCH PAPER

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## Effect of water stress on remobilization ability and yield components of wheat varieties

Aineh Kar Hasan<sup>1</sup>, Eradatmand Asli, Davood<sup>2</sup>, Yousefi Rad, Mojtaba<sup>1</sup>

<sup>1</sup>*Department of Agronomy and Plant Breeding, Saveh Branch, Islamic Azad University, Saveh, Iran*

<sup>2</sup>*Department of Agriculture, Payame Noor University, Tehran, Iran*

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### Abstract

Drought, as an abiotic stress, is multidimensional in nature, and it affects plants at different levels of their organization especially photosynthesis. Wheat is generally grown on arid-agricultural fields. Drought often causes serious problems in wheat production. This investigation was conducted to study the remobilization of storage materials and yield component. Four wheat (*Triticum aestivum* L.) cultivars including Back cross roshan, Pishtaz, Bahar and Falat were evaluated in a split plot experiment based on randomized complete block design with three replications. Water stress was imposed by withholding irrigation before flowering. Seed weight in spike, 1000 grain weight, seed yield and harvesting index decreased under water stress before flowering stage and remobilization of stored assimilates was relatively higher under water-stress condition as compared with the well-watered environment. Also remobilization efficiency and increased under water stress. Back cross roshan had the highest yield under both situation.

\* **Corresponding Author:** Aineh Kar Hasan ✉ [hassan\\_1346@yahoo.com](mailto:hassan_1346@yahoo.com)

## Introduction

Drought stress is a major factor affecting crop production in arid and semi arid climates. It inhibits plant growth and development, with impact of various biochemical and physiological processes such as photosynthesis, respiration, nutrient transport, carbohydrates and ion absorption and metabolism of nutrient (Farooq *et al.*, 2009; Rafieet *et al.*, 2003).

Plant's ability to survive and continue its growth and photosynthesis in the environmental stresses is dependent on the genetic potential of plant that indicates as the molecular and physiological responses (Mohsenzadeh *et al.*, 2003). (Farshadfar *et al.*, 2008) reported that there is a negative correlation between grain yield and total grain protein under dry conditions. Moreover drought stress affects plant morphological characteristics such as leaf area, plant height, biomass weight, seed weight and finally yield and physiological characteristics of the plant such as leaf gas exchange and Chlorophyll fluorescence, photosynthetic activity, leaf nitrogen concentration, leaf water status, free amino acids and soluble proteins, activity of some enzymes such as nitrate reductase and finally restrict plants growth (Sio-Se Marde *et al.*, 2006; Mohammadkhani and Heidari, 2007) (Abdel-hadi BA, 2007).

Wheat is the most important crop plant grown in the semi-arid regions of Iran in which usually experiences water stress during grain filling period. Under such conditions, normal grains could be obtained if pre-anthesis stored carbohydrates in the stem can be remobilized efficiently (Blum *et al.*, 1983a, Blum *et al.*, 1983b, Ehdaie and Waines 1996). Pre-anthesis assimilates were shown to provide up to 27% of the final grain yield (Bedinger *et al.*, 1977) and even more under dry environmental conditions (Pheloung and Siddique, 1991). When wheat plants exposed to drought stress occurs a decrease in Stomatal conductance and increase intercellular carbon dioxide concentration (Nazemosadat and Kazemini, 2008). Though environmental conditions significantly affect genotypes ability to remobilize the stored assimilates. The aim of our study was to investigate the effects of

water deficit stress on dry matter remobilization and grain yield on different wheat digits.

## Materials and methods

### *Experimental field and meteorological conditions*

This experiment was conducted under semicontrolled conditions in the Shirzad Barzegar field of Sheer Khaan castle's village saveh province (35°2' N, 50°21' E and 1045 alt. and 206 mm mean annual rainfall), Iran, between june to july 2010. Soil was clay-sandy. The soil test values indicated a pH of 8, 0.05% total N and 0.5% C.

### *Plant materials and experimental design*

Seeds of four wheat digits including Pishtaz, Back cross roshan, Bahar and Falat which were recommended for planting in warm dry land conditions of central parts of Iran, were sown in 5×1 square meter experimental plots. All plots were normally irrigated every 12 day. Split plot experiment in randomized complete block design with three replications and two factors including cultivar and drought stress was conducted.

Water treatment include: 1- full irrigation(witness), 2: Drought treatment was imposed by restricting irrigation before flowering phase(before belly until the beginning milky phase of seeds) and the second attendance include different wheat digits: 1- Pishtaz 2- Back cross roshan 3- Bahar and Falat that performed in three repetitions. The plots were watered uniformly until the flowering stage.

### *Data collection*

In order to measure the photosynthetic substances remobilization at each plot, 20 plants were selected randomly at anthesis and maturity. Then the leaves and stems were removed from samples. In both sampling phases for obtaining the stable dry matter weight, the samples were placed in an oven at 70-72°C. The dry matter remobilization before anthesis can be evaluated based on dry matter remobilization (DMT t ha<sup>-1</sup>) and the contribution of photosynthetic in grain before anthesis:

$$DMT = \frac{TDM_{anthesis} - (TDM_{maturity} - Seedweight)}{(TDM_{maturity} - Seedweight)} * 100$$

### Statistical treatment

The data were analyzed using SAS (1997). The analysis of variance was conducted using the general linear model and means were tested by least significant difference at  $P < 0.05$  level.

### Result and discussion

The result of this study showed that drought stress and digit had significant effect on Seed weight in spike, 1000 grain weight, seed yield, biological yield, harvest index, remobilization and remobilization efficiency. While the interaction effects of drought stress and digit just was significant for 1000 weight seed and remobilization (Table1). According the result of means, Bahar digit had highest seed weight in spike under full irrigation (2.45g) and Falat showed lowest seed weight in spike under drought stress before flowering (1.41g) (Table 4).

**Table 1.** Analysis of variance of the effects of drought stress and digit on some traits of wheat.

SOV	df	Seed weight in spike	1000 grain weight	Seed yield	Biological yield	Harvest index	Remobilization	Remobilization efficiency
Replication	2	0.21 <sup>*</sup>	18.37 <sup>ns</sup>	8261.5 <sup>**</sup>	18882.53 <sup>*</sup>	12.59 <sup>ns</sup>	202.23 <sup>ns</sup>	0.08 <sup>ns</sup>
Drought stress (a)	1	1.43 <sup>**</sup>	64.67 <sup>**</sup>	34572.98 <sup>**</sup>	9690.25 <sup>**</sup>	190.5 <sup>**</sup>	3085.46 <sup>**</sup>	36.91 <sup>**</sup>
Error	2	0.004	0.31	1480.27	14603.18	76.64	0.54	0.05
Digit (b)	3	0.33 <sup>**</sup>	53.95 <sup>**</sup>	48841.78 <sup>**</sup>	47015.44 <sup>**</sup>	297.96 <sup>**</sup>	2139.75 <sup>**</sup>	5.37 <sup>**</sup>
A <sup>a</sup> b	3	0.05 <sup>ns</sup>	25.48 <sup>**</sup>	604.56 <sup>ns</sup>	4037.04 <sup>ns</sup>	22.24 <sup>ns</sup>	311.35 <sup>*</sup>	0.6 <sup>ns</sup>
Error	12	0.03	4.91	850.12	3515.62	12.36	86.25	0.3
CV		9.75	5.78	5.8	5.75	7.22	6.86	4.64

\* and \*\*: Significant at 5% and 1% probability levels, respectively. ns: Non-significant.

**Table 2.** Mean comparison of water stress on some investigated traits.

Drought stress	Seed weight in spike	1000 grain weight	Seed yield	Biological yield	Harvest index	Remobilization	Remobilization efficiency
Full irrigation	2.14 <sup>a</sup>	39.97 <sup>a</sup>	540.76 <sup>a</sup>	1051.72 <sup>a</sup>	51.53 <sup>a</sup>	123.98 <sup>b</sup>	10.51 <sup>b</sup>
Stop irrigation	1.65 <sup>b</sup>	36.69 <sup>b</sup>	464.85 <sup>b</sup>	1011.53 <sup>b</sup>	45.9 <sup>b</sup>	144.66 <sup>a</sup>	12.99 <sup>a</sup>

Means with similar letters within a column are not significantly different at 5 % level according to DMRT.

1000 grain weight varied from 34.2 g to 44.06 g between digits under full irrigation. Highest amount of it belongs to Bahar digit and lowest amount belongs to Falat digit. Also Pishtaz and Falat had the highest and lowest amount of 1000 grain weight respectively (40.55 & 34.2) (table4). The effect of drought and well watered regimes on grain yield is displayed in Tab. 4. Yields (calculated as  $\text{gm}^{-2}$ ) in well watered plots varied from 410.94 to 630.38  $\text{gm}^{-2}$  and under the drought condition they varied from 351.78 to 545.91  $\text{gm}^{-2}$ . Back cross roshan was the best yielding in both well watered conditions and drought stress before flowering mainly due to number of grains per spike, whereas Pishtaz was the lowest yielding because of its lower grain grains per spike (Tab. 2). Grain yield was greater in well watered environment than in the drought environment, a

consequence of more spikes per square meter, heavier grains, and a longer plant cycle.

Significant difference was observed between digits in regard to biological yield (Tab.1, Tab.2). Also well irrigation and drought stress affected biological yield significantly (Tab. 2). But The interaction of water stress and digit on biological yield wasn't significant (Tab.1). Harvest index under imposed well-watered and water stress before flowering, varied significantly and was 51.53% and 45.9%, respectively (Tab. 2). Falat and Pishtaz showed the highest and lowest harvest index (56.5%) and (39.76%) respectively. The interaction of mentioned traits on harvesting index wasn't significant (Tab. 1). Drought stress and digit had significant effect on remobilization and remobilization efficiency but the

interaction of them was just significant for remobilization. The highest amount of mentioned traits belongs to Back cross roshan in both full

irrigation and drought stress (Tab. 4). Also Pishtaz had the highest grain share performance percentage of remobilization in both situation (Tab. 4).

**Table 3.** Mean comparison of digit, water stress on some investigated traits.

Digit	Seed weight 1000 in spike	grain weight	Seed yield	Biological yield	Harvest index	Remobilization	Remobilization efficiency
Pishtaz	1.69 <sup>b</sup>	41.65 <sup>a</sup>	381.36 <sup>d</sup>	959.73 <sup>c</sup>	39.76 <sup>c</sup>	113.49 <sup>c</sup>	10.73 <sup>b</sup>
Back cross roshan	2.1 <sup>a</sup>	37.8 <sup>b</sup>	588.14 <sup>a</sup>	1153.28 <sup>a</sup>	51.23 <sup>b</sup>	159.14 <sup>a</sup>	12.73 <sup>a</sup>
Bahar	2.09 <sup>a</sup>	39.37 <sup>ab</sup>	491.37 <sup>c</sup>	1040.68 <sup>b</sup>	47.35 <sup>b</sup>	130.84 <sup>b</sup>	11.18 <sup>b</sup>
Falat	1.69 <sup>b</sup>	34.51 <sup>c</sup>	550.33 <sup>b</sup>	972.82 <sup>bc</sup>	56.5 <sup>a</sup>	137.81 <sup>b</sup>	12.35 <sup>a</sup>

Means with similar letters within a column are not significantly different at 5 % level according to DMRT.

**Table 4.** Effect of water condition and digits on some investigated traits.

Irrigation	Digit	Seed weight 1000 in spike	grain weight	Seed yield	Biological yield	Harvest index	Remobilization	Remobilization efficiency
Full irrigation	Pishtaz	1.87 <sup>bcd</sup>	42.47 <sup>a</sup>	410.94 <sup>cd</sup>	1007.83 <sup>bc</sup>	40.9 <sup>cd</sup>	109.11 <sup>f</sup>	9.68 <sup>e</sup>
Full irrigation	Back cross roshan	2.25 <sup>ab</sup>	38.27 <sup>bc</sup>	630.38 <sup>a</sup>	1176.66 <sup>a</sup>	54.15 <sup>ab</sup>	137.7 <sup>bcd</sup>	11.07 <sup>cd</sup>
Full irrigation	Bahar	2.45 <sup>a</sup>	44.06 <sup>a</sup>	541.51 <sup>b</sup>	1025.97 <sup>abc</sup>	52.83 <sup>ab</sup>	121.45 <sup>def</sup>	10.24 <sup>de</sup>
Full irrigation	Falat	1.97 <sup>bc</sup>	34.82 <sup>c</sup>	580.2 <sup>ab</sup>	996.43 <sup>bc</sup>	58.24 <sup>a</sup>	127.67 <sup>cde</sup>	11.05 <sup>cd</sup>
Drought stress	Pishtaz	1.5 <sup>de</sup>	40.55 <sup>ab</sup>	351.78 <sup>d</sup>	911.64 <sup>c</sup>	38.63 <sup>d</sup>	117.88 <sup>ef</sup>	11.79 <sup>bc</sup>
Drought stress	Back cross roshan	1.95 <sup>bc</sup>	37.33 <sup>bc</sup>	545.91 <sup>b</sup>	1129.9 <sup>ab</sup>	48.31 <sup>bc</sup>	180.58 <sup>a</sup>	14.39 <sup>a</sup>
Drought stress	Bahar	1.73 <sup>cde</sup>	34.68 <sup>c</sup>	441.23 <sup>c</sup>	1055.39 <sup>abc</sup>	41.87 <sup>cd</sup>	140.23 <sup>bc</sup>	12.12 <sup>b</sup>
Drought stress	Falat	1.41 <sup>e</sup>	34.2 <sup>c</sup>	520.47 <sup>b</sup>	949.22 <sup>c</sup>	54.77 <sup>ab</sup>	147.95 <sup>b</sup>	13.66 <sup>a</sup>

Means with similar letters within a column are not significantly different at 5 % level according to DMRT.

According the result of (Ehdaie *et al.*, 2006, Gebbing *et al.*, 1999 \$ Kobata *et al.*, 1992 ) cessation of irrigation before flowering reduced stored carbohydrate, thereby reducing carbohydrate transport from the source to the seed resulting in reduced seed weight. Reducing moisture in the grain filling period reduces current photosynthesis during this period , resulting in reduction seed weight (Evans, 1993). Studies show that grain yield under water stress due to early cessation in transferring of sucrose, because of reducing in photosynthesis after flowering as well as reduces photosynthesis remobilization. (Kobat *et al.*, 1992, 2003 ‘Weschke *et al.*, 2003). Lack of water near the flowering stage, significantly reduces seed formation and fertility, while drought stress at seed filling stage ,reduced transferring of photosynthesis substance, resulting in reduced seed weight and seed shrink so photosynthetic production and remobilization of

them are closely related to the stage of drought stress occurred (Machado *et al.*, 1993). Differences in biological yield between digits in regard to drought stress is likely related to differences in growth habit. Wheat is a plant with limited growth and there is a cessation in vegetative growth after anthesis but stop in vegetative growth differ in different digits. (Foulkes *et al.*, 2006) reported that there is a reduction in biomass production in different varieties under drought stress so that in some varieties , reduction in biological yield was observed up to 6 tons per hectare. The results of our study are in good agreement with findings of (Eliasi *et al.*, 2009) which they reported considerable variation in remobilization after drought stress. They remarked that there is a long time for increasing stem weight under drought stress before flowering and water deficit enhanced the amount of dry matter restoration and dry matter remobilization to grain. Also (Ehdaii & winz, 1996) reported that the

average remobilization in water stress condition (44.6%) is higher than well water condition (29.5%). Before anthesis the amount of photosynthetic substances is greater than plant demand, therefore additional photo-assimilates accumulate in shoot and eventually these assimilates are stored in secondary sources, such as stem, peduncle and leaves. These stored assimilates can be used during grain filling period for economical yield. The occurrence of environmental stresses such as drought, especially during grain filling, decreases the photosynthesis, and the importance of secondary sources in grain filling are more pronounced. In general, each factor which limits the photosynthesis after anthesis, especially during grain filling, can be effective on remobilization from secondary sources. It may be postulated that when wheat digits encounter water deficit before flowering stage, although yield is decreased compared to normal condition, the rate of dry matter transfer and remobilization efficiency and percentage increase

### Conclusion

In general, we concluded that the occurrence of environmental stress such as water deficit before flowering stage causes the increase of remobilization and remobilization efficiency whereas reduces the grain weight in spike and 1000 grain weight, which led to decrease in the final grain yield, while in non-stress condition the higher yields were obtained. Under drought stress condition, back cross roshan produced the highest grain yield in both situation indicating that this digit could tolerate drought stress better than other digit through using stored reserves via remobilization.

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