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Evaluation of Some Growth Factors of Bread Wheat Varieties under Drought Stress Conditions

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ABSTRACT

In this research, some growth factors of bread wheat varieties were evaluated under drought stress conditions. Irrigation stop in different growth stages of bread wheat varieties considered as the main treatment including T1:irrigation stop in heading stage, T2:irrigation stop in flowering stage, T3:irrigation stop in milk grain stage and T4:normal irrigation. Different varieties of bread wheat (Triticumaestivum) considered as the secondary treatments. They were Zarin, Alvand, Gaskozhen and Sayonz. The results showed that Alvand and Zarin varieties were the best bread wheat varieties in Sanandaj region respectively. Besides, normal irrigation had the best result in increasing of more of growth factors of bread wheat varieties.

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INTRODUCTION

Crop productivity in semiarid regions is mainly limited by water availability [6]. Water shortage is a major abiotic stress for crop production worldwide, limiting the productivity of crop species, especially in dry land agricultural areas [5,16]. Wheat is the most basic calorie and protein source and one of the most important crops in the world about 33 million ha of the world's wheat-cultivated lands, face drought damage of which is considerable at global level [21,22].Drought is the most common environmental stress affecting about 32% of 99 million hectares under wheat cultivation in developing countries and at least 60 million hectares under wheat cultivation in developed countries [23]. Water stress is major harmful factor in arid and semiarid regions worldwide [24] that limits the area under cultivation and yield of crops. Drought stress may occur throughout the growing season, early or late season, but its effect on yield reduction is highest when it occurs after anthesis [4]. Morphological characters such as root length, tiller, number of spike per m^2, grain per spike number, fertile tillers per plant, 1000 grain weight, peduncle length, spike weight, stem weight, awn length, grain weight per spike etc. affect the wheat tolerance to the moisture shortage in the soil [17,18]. Water stress not only affects the morphology but also severely affects the metabolism of the plant. The extent of modification depends upon the cultivar, growth stage, duration and intensity of stress [14,2]. All of crop growth stages are not uniformly susceptible to water scarcity. On the other hand, some stages can cope-up with water shortage very well, while others are more susceptible and water shortages at such stages may result in distinct yield losses.

Moisture stress is known to reduce biomass, tillering ability, grains per spike and grain size at any stage when it occurs. So, the overall effect of moisture stress depends on intensity and length of stress [3]. Selecting wheat genotypes that could tolerate drought stress and produce acceptable yield has been the major challenge for the wheat breeders in the past 50 years [13]. It has been found that under the drought stress conditions, those genotypes that show the highest harvest index and highest yield stability are drought tolerant [25]. It is the need of time to develop the varieties, which have drought tolerant potential to increase area under cultivation and yield of wheat crop. Regulated, deficit irrigation provides a means of reducing water consumption while minimizing adverse effects on yield [19]. By deficit irrigation, crops are deliberately under irrigated during plant growth stages that are relatively insensitive to water stress. Optimum crop yields under deficit irrigation practices can be obtained by allowing a certain level of yield reduction of a given crop or area in order to divert the saved water to irrigate other areas or crops[15,28].The objectives of the present study were to find the best varieties of bread wheat (*Triticumaestivum*) under drought stress conditions in Sanandaj region of Iran.

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MATERIALS AND METHODS

1-3: Geographical location:

This study was conducted in experimental farm of Agriculture and Natural Resource Center of Gerizeh that was located in south of Sanandaj city from Kurdistan province of Iran. This experimental farm was located in longitude and latitude of 47°1' eastern and 35°16' northern respectively and its height was 1405 meters above the sea level.

2-3: Weather characteristics of the region:

According to the 50-year statistics, the average of annual rainfall was 471 mm, the average of maximum temperature was 21.3 °C, the mean minimum temperature was 5.4 °C and the mean wind speed was 3.9 knot.

3-3: Soil characteristics:

Composite samples of 5 random points from 0-30 cm depth of cultivated land, in the farm were taken. The results are presented in Table 1.

Table 1: Some physical and chemical properties of the soil before planting test

Size of soil particles (%)			Soil texture	EC (ds/m)	pH	Organic carbon (%)	Soluble phosphorus (ppm)	Soluble potassium (ppm)	Depth (cm)
Clay	Silt	Sand							
18	36	46	Loam	0.8	7.1	0.74	10	180	0-30

4-3: Experimental plan:

This plan was performed as a split plot in a randomized complete block design with 16 treatments and 3 replications. Irrigation stop in different stages of bread wheat varieties growth considered as the main treatment, including $\mathbf{T_{1:}}$irrigation stop in heading stage, $\mathbf{T_{2:}}$irrigation stop in flowering stage, $\mathbf{T_{3:}}$irrigation stop in milk grain stage and $\mathbf{T_{4:}}$normal irrigation. Different varieties of bread wheat (*Triticumaestivum*) considered as the secondary treatments. They were Zarin, Alvand, Gaskozhen and Sayonz. Thus, with 16 treatments and 3 replications, 48 plots were tested.

5-3: Farming operations:

Each variety was planted in a separated plot and irrigation was performed according to experimental plan. Normal irrigation was according to usage of soil moisture index or soil metric potential. In this method, the soil moisture percentage was measured thorough sampling of plant root at days before irrigation. When the weight mean of soil moisture reached to the allowed depletion, the irrigation process happened. For irrigation, the following equation used[1]:

$$SMD = \left(\theta_{fc} - \theta_i\right).B_d.D_r \tag{1}$$

Where

SMD: soil moisture deficit (cm), θ_{fc}: field capacity moisture, θ_i: weight percent of available moisture in the soil of farm, B_d: bulk density (gr/cm^3) and Dr: plant root depth (cm). Each variety was planted in 9 lines with length of 6 meters and space of 20 centimeters. The density of planting was about350-400 grains per m^2.

6-3: Evaluated characteristics in this plan:

Evaluated characteristics in this plan are: plant height, plant weight, peduncle length, stem weight, root length, fertile claw number, leaf area and leaf weight. For evaluating of these characteristics, 10 plants selected from each plot and finally measured the average of them. In addition, for evaluating of fertile claw number, 0.25 m^2 of each plot was considered.

RESULTS AND DISCUSSION

1-4: Plant height:

The effect of irrigation treatments on plant height was not significant (Figure1). However, normal irrigation had the most plant height (83.84 cm) and irrigation stop in heading stage had the least plant height (80.64 cm). In addition, the effect of different varieties on plant height was significant at 1% level (Figure 2). Whereas, Alvand variety had the most plant height (93.31 cm) and Gaskozhen variety had the least plant height (71.36).Reciprocal effect of treatments showed that Gaskozhen variety with irrigation stop in heading stage had the least plant height (67.86 cm) and Zarin variety with normal irrigation had the most plant height (98.86 cm), whereas the difference between them was significant at 1% level (Figure 3). Drought stress in heading stage had the most effect on reduction of plant height. Because drought stress in heading stage reduces plant vegetative growth, reduces internodes length and finally reduces plant height. Therefore, irrigation stop in heading stage can reduce plant height. This result is confirmed by Radmehr [20] Shahidi [26] and Khodadadidehkordi *et al* [9].

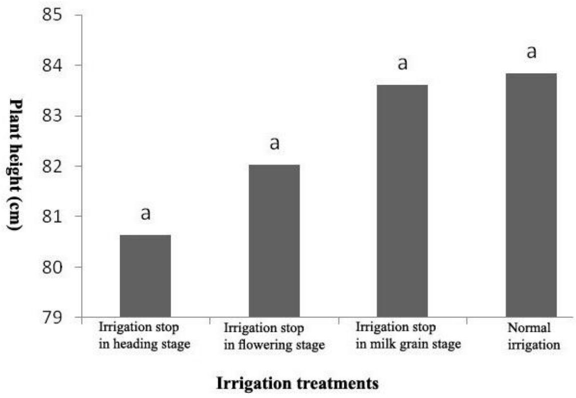

Fig. 1: Plant height on base of irrigation treatments.

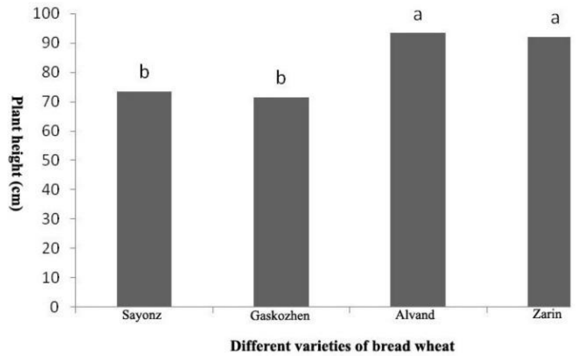

Fig. 2: Plant height on base of different varieties of bread wheat.

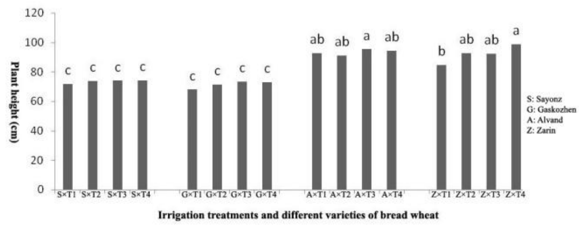

Fig. 3: Reciprocal effect of irrigation treatments and different varieties of bread wheat.

2-4: Peduncle length:

The effect of irrigation treatments on peduncle length was not significant (Figure 4). However, normal irrigation had the most peduncle length (35.34 cm) and irrigation stop in heading stage had the least peduncle length (32.21 cm). In addition, the effect of different varieties on peduncle length was significant at 1% level (Figure 5). Whereas, Alvand variety had the most peduncle length (38.31 cm) and Gaskozhen variety had the least peduncle length(28.68). Reciprocal effect of treatments showed that Gaskozhen variety with irrigation stop in heading stage had the least peduncle length (28.29 cm) and Zarin variety with normal irrigation had the most peduncle length (45.49 cm), whereas the difference between them was significant at 1% level (Figure 6). Peduncle length is one of the important parts in plant nutrition transition and if it be long, it will be a privilege in drought stress conditions, because plant has consumed the more carbohydrates for growth and maintaining itself in drought stress conditions. Drought stress in heading stage had the most effect on reduction of peduncle length. Because drought stress in heading stage reduces plant vegetative growth, reduces internodes length and finally reduces peduncle length. Therefore, irrigation stop in heading stage can reduce peduncle length. This result is confirmed by Hekmat-Shoar [8].

Advances in Environmental Biology, 8(7) May 2014, Pages: 2251-2261

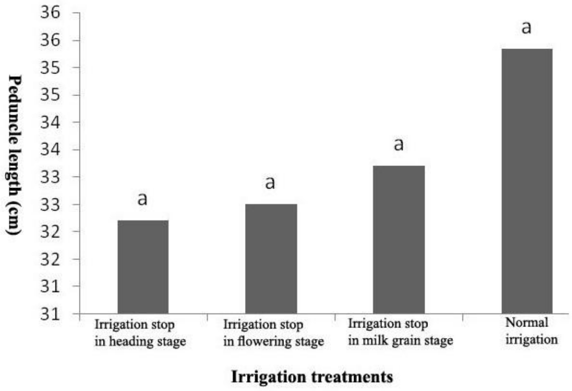

Fig. 4: Peduncle length on base of irrigation treatments.

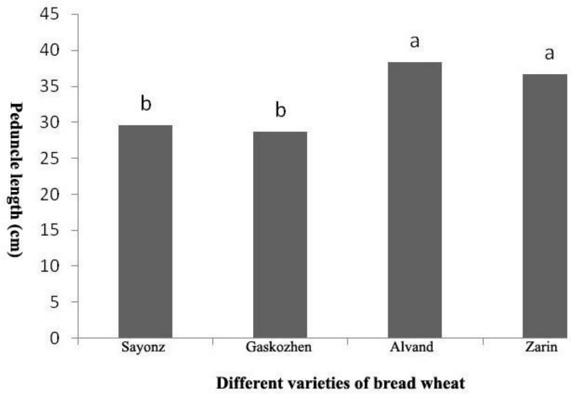

Fig. 5: Peduncle length on base of different varieties of bread wheat.

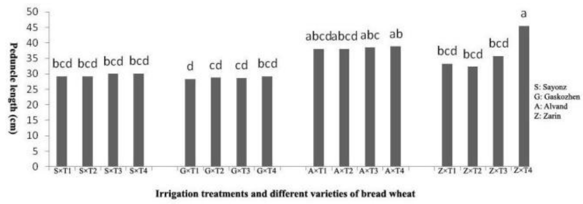

Fig. 6: Reciprocal effect of irrigation treatments and different varieties of bread wheat.

3-4: Stem weight:

The effect of irrigation treatments on stem weight was significant at 1% level (Figure 7). However, irrigation stop in milk grain stage had the least stem weight (1.6 gr) and normal irrigation had the moststem weight (1.94 gr). In addition, the effect of different varieties on stem weight was significant at 1% level (Figure 8). Whereas, Zarin variety had the most stem weight (1.93 gr) and Sayonz variety had the least stem weight (1.52 gr). Reciprocal effect of treatments showed that Sayonz variety with irrigation stop in flowering stage had the least stem weight (1.15 gr) and Zarin variety with normal irrigation had the most stem weight (2.28 gr), whereas the difference between them was significant at 1% level (Figure 9). Drought stress in milk grain stage had the most effect on reduction of stem weight. Because, drought stress reduces photosynthesis in plant, therefore plant for filling grains, transfers stored nutrition in stem to grains, this process reduces stem weight. So, irrigation stop in milk grain stage can reduce stem weight. This result is confirmed by Kobata *et al*[10].

Advances in Environmental Biology, 8(7) May 2014, Pages: 2251-2261

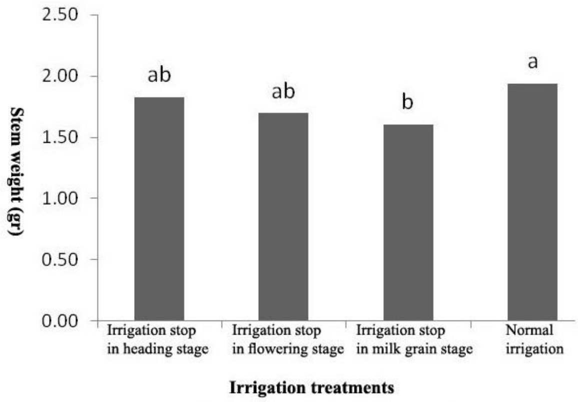

Fig. 7: Stem weight on base of irrigation treatments.

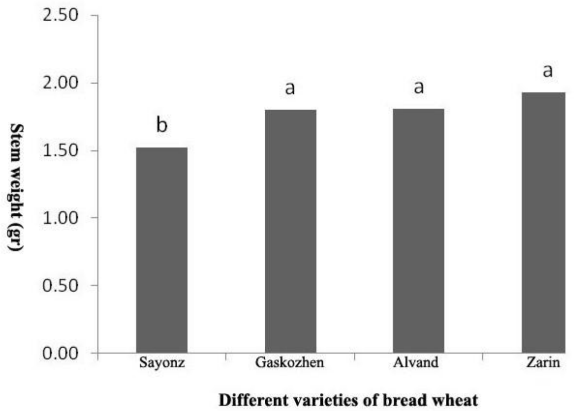

Fig. 8: Stem weight on base of different varieties of bread wheat.

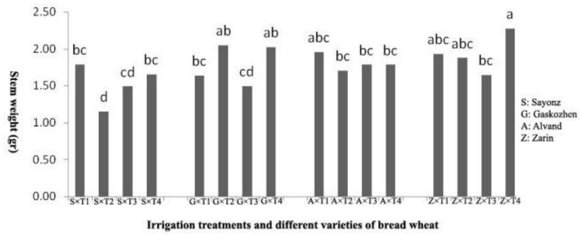

Fig. 9: Reciprocal effect of irrigation treatments and different varieties of bread wheat.

4-4: Plant weight:

The effect of irrigation treatments on plant weight was significant at 1% level (Figure 10). However, irrigation stop in flowering stage had the least plant weight (4.9 gr) and normal irrigation had the most plant weight (6.04 gr). In addition, the effect of different varieties on plant weight was significant at 1% level (Figure 11). Whereas, Alvand variety had the most plant weight (5.98 gr) and Sayonz variety had the least plant weight (4.56 gr). Reciprocal effect of treatments showed that Sayonz variety with irrigation stop in flowering stage had the least plant weight (3.35 gr) and Zarin variety with normal irrigation had the most plant weight (7.08 gr), whereas the difference between them was significant at 1% level (Figure 12). Drought stress in each plant growth stage causes reduction in plant weight. Whereas, drought stress in heading stage reduces plant height, peduncle length and spike length. In addition, drought stress in flowering stage reduces fertilized grains number in spike and drought stress in milk grain stage reduces the grains weight. All of these characteristics have significant correlation with plant weight and the reduction of them reduces the plant weight.

Advances in Environmental Biology, 8(7) May 2014, Pages: 2251-2261

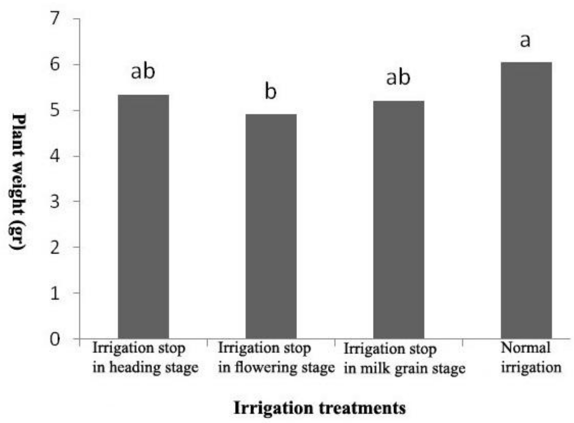

Fig. 10: Plant weight on base of irrigation treatments.

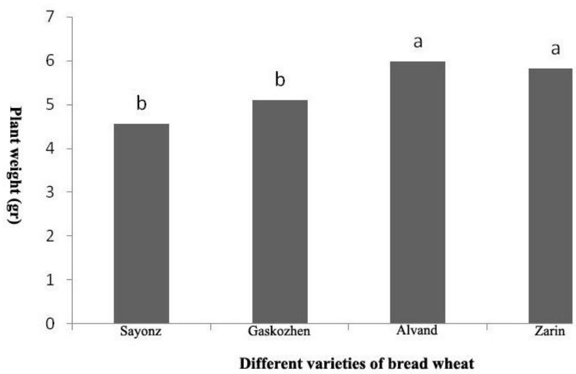

Fig. 11: Plant weight on base of different varieties of bread wheat.

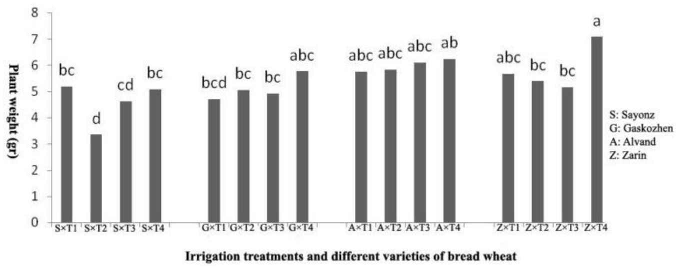

Fig. 12: Reciprocal effect of irrigation treatments and different varieties of bread wheat.

5-4: Leaf weight:

The effect of irrigation treatments on leaf weight was not significant (Figure 13). However, irrigation stop in flowering stage had the least leaf weight (0.098 gr) and irrigation stop in heading stage had the most leaf weight (0.122 gr). In addition, the effect of different varieties on leaf weight was significant at 1% level (Figure 14). Whereas, Alvand variety had the most leaf weight (0.13 gr) and Sayonz variety had the least leaf weight (0.09 gr). Reciprocal effect of treatments showed that Sayonz variety with irrigation stop in flowering stage and Zarin variety with irrigation stop in milk grain stage had the least leaf weight (0.07 gr) and Alvand variety with irrigation stop in heading stage had the most leaf weight (0.16 gr), whereas the difference between them was significant at 1% level (Figure 15). Drought stress in flowering and milk grain stages causes that leaves don't produce the more photosynthetic matters than normal irrigation, also plant for filling grains, transfers stored nutrition in leaves to grains, Therefore this process reduces leaves weight and causes leaves early oldness. This result is confirmed by Kiniry [11].

Advances in Environmental Biology, 8(7) May 2014, Pages: 2251-2261

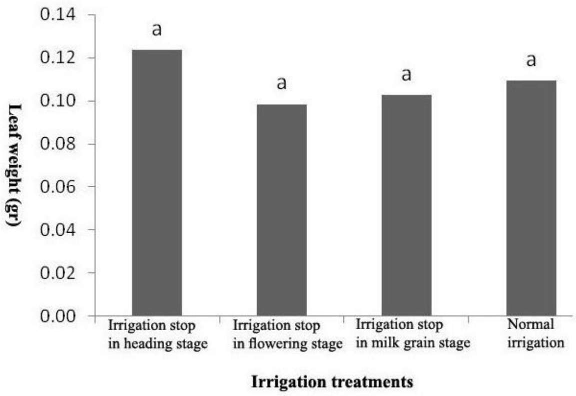

Fig. 13: Leaf weight on base of irrigation treatments.

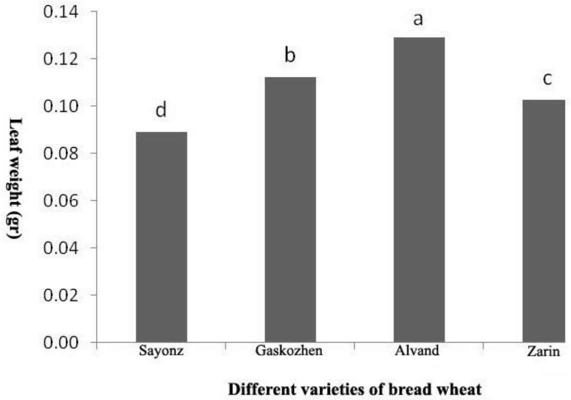

Fig. 14: Leaf weight on base of different varieties of bread wheat.

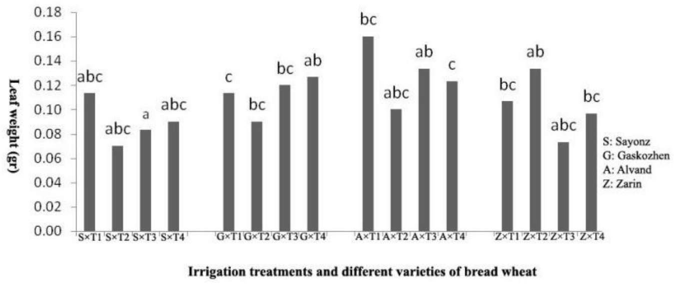

Fig. 15: Reciprocal effect of irrigation treatments and different varieties of bread wheat.

6-4: Leaf area:

The effect of irrigation treatments on leaf area was significant at 1% level (Figure 16). However, normal irrigation had the most leaf area (7.81 cm^2) and irrigation stop in milk grain stage had the least leaf area (5.86 cm^2). In addition, the effect of different varieties on leaf area was significant at 1% level (Figure 17). Whereas, Gaskozhen variety had the most leaf area (7.65 cm^2) and Alvand variety had the least leaf area (5.47 cm^2). Reciprocal effect of treatments showed that Alvand variety with irrigation stop in heading stage had the least leaf area (4 cm^2) and Gaskozhen variety with normal irrigation had the most leaf area (10.83 cm^2), whereas the difference between them was significant at 1% level (Figure 18). Drought stress reduces Nitrogen accumulation in leaves. Also, drought stress in milk grain stagereduces Nitrogen accumulation in grains. So, grains Nitrogen are compensated by remobilization process in plant. Increasing in Nitrogen remobilization and reduction in photosynthetic activities causes reduction in leaf area and leaves early oldness. This result is confirmed by Federick and Camberato[7].

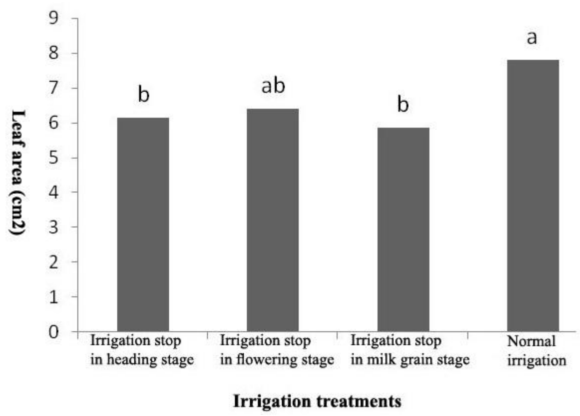

Fig. 16: Leaf area on base of irrigation treatments.

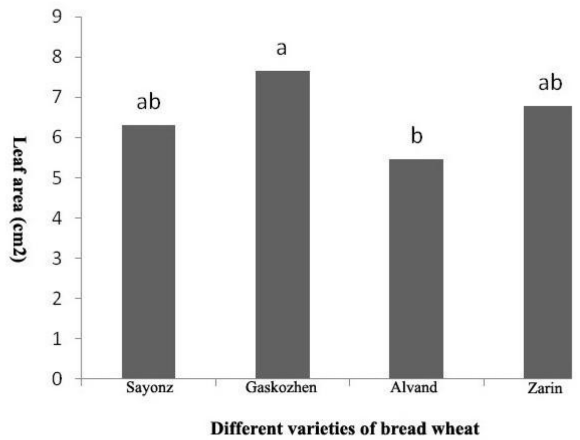

Fig. 17: Leaf area on base of different varieties of bread wheat.

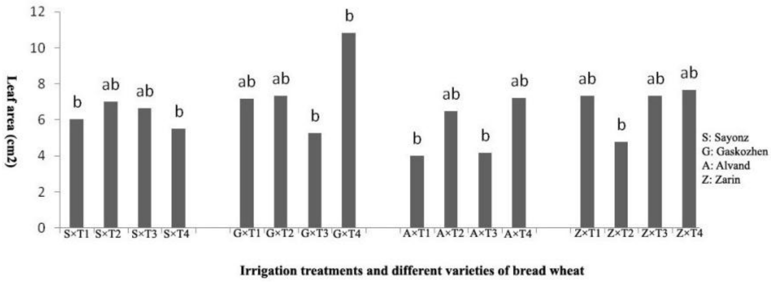

Fig. 18: Reciprocal effect of irrigation treatments and different varieties of bread wheat.

7-4: Fertile claw number:

The effect of irrigation treatments on fertile clawnumber was significant at 1% level (Figure 19). However, normal irrigation had the most fertile clawnumber (107.48) and irrigation stop in heading stage had the least fertile clawnumber (100.49). In addition, the effect of different varieties on fertile clawnumber was not significant (Figure 20). Whereas, Zarin variety had the most fertile clawnumber (104.66) and Sayonz variety had the least fertile clawnumber (103.84). Reciprocal effect of treatments showed that Sayonz variety with irrigation stop in heading stage had the least fertile clawnumber (96.99) and Sayonz variety with normal irrigation had the most fertile clawnumber (109.23), whereas the difference between them was significant at 1% level (Figure 21). Drought stress in heading stage had the most effect on reduction of fertile clawnumber and reduces grain yield. In drought stress conditions, plant cannot produce enough photosynthetic matters and cannot afford to increase fertile clawnumber. Grains number per area unit are determined by fertile clawsnumber and grains number per spike. This result is confirmed by Keimand Kronstad[12].

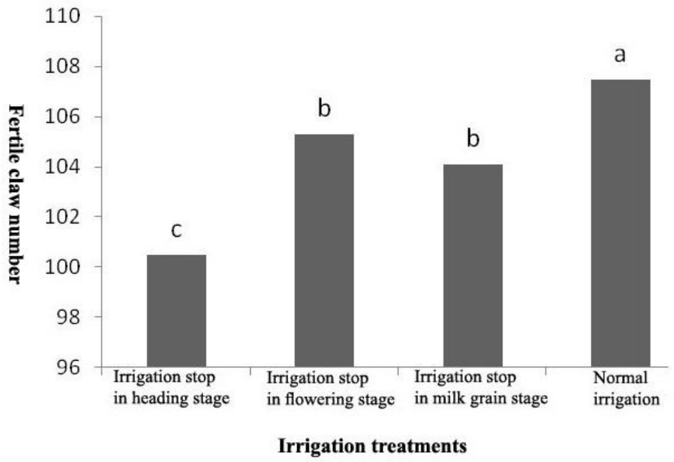

Fig. 19: Fertile clawnumber on base of irrigation treatments.

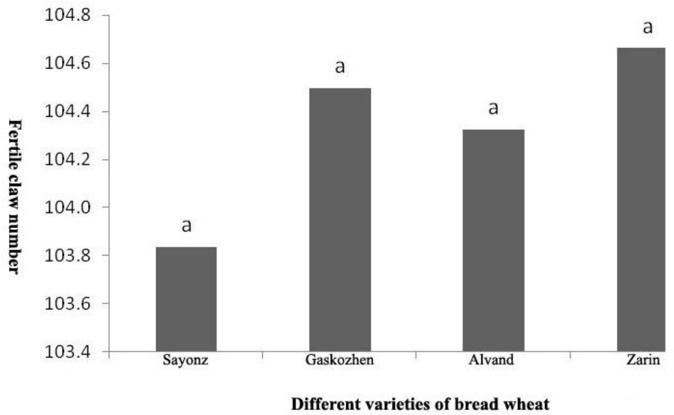

Fig. 20: Fertile clawnumber on base of different varieties of bread wheat.

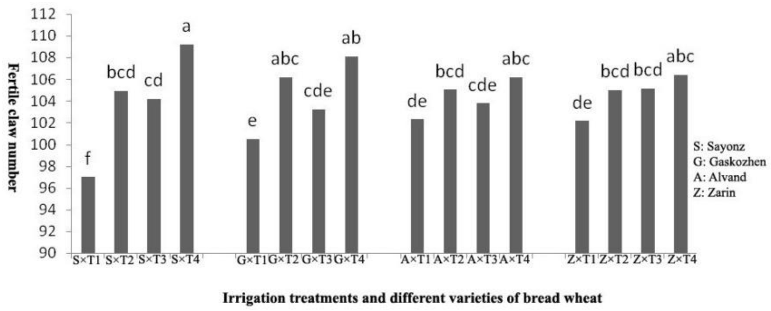

Fig. 21: Reciprocal effect of irrigation treatments and different varieties of bread wheat.

8-4: Root length:

The effect of irrigation treatments on root length was significant at 1% level (Figure 22). However, irrigation stop in heading stage had the most root length(17.07 cm) and normal irrigation had the least root length(13.83 cm). In addition, the effect of different varieties on root length was not significant (Figure 23). Whereas, Sayonz variety had the most root length(15.73 cm) and Zarin variety had the least root length(14.13 cm). Reciprocal effect of treatments showed that Zarin variety with normal irrigation had the least root length(12.54 cm) and Sayonz variety with irrigation stop in heading stage had the most root length(18.08 cm), whereas the difference between them was significant at 1% level (Figure 24). Drought stress in heading stage had the most effect on increasing of root length. Actually, drought stress in heading stage causes that plant for compensating of its moisture deficit extends its root length for finding more moisture. So, irrigation stop in heading stage can increase root length. This result is confirmed by Tupitsyn*et al*[27].

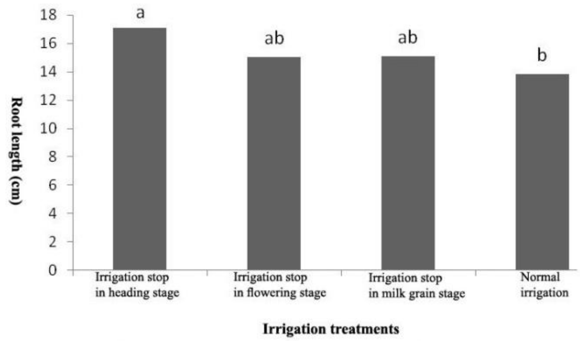

Fig. 22: Root length on base of irrigation treatments.

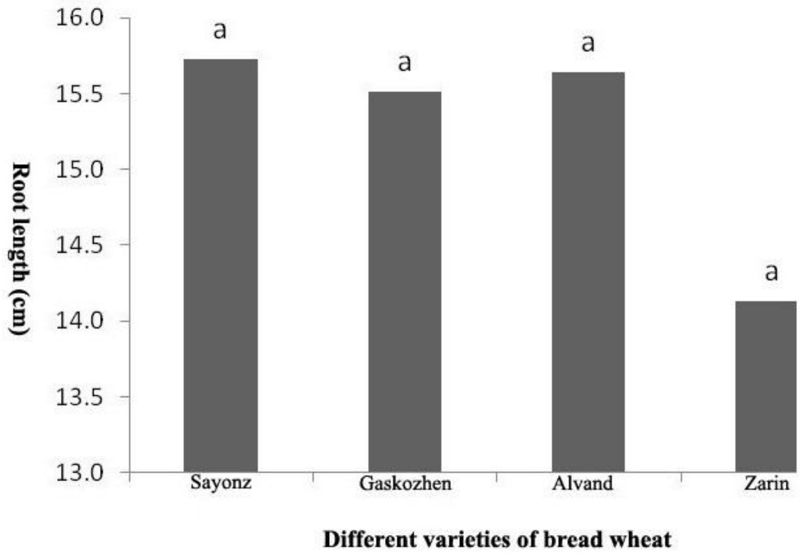

Fig. 23: Root length on base of different varieties of bread wheat.

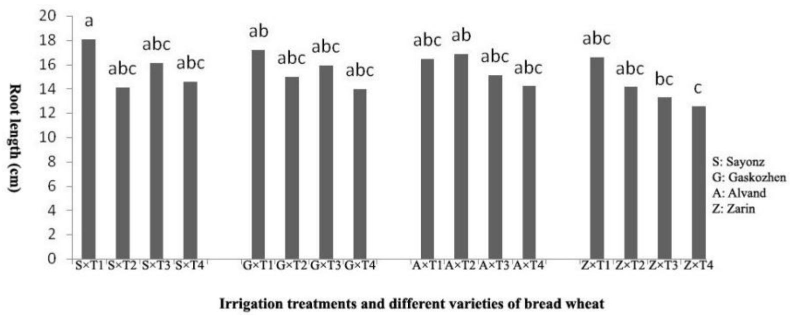

Fig. 24: Reciprocal effect of irrigation treatments and different varieties of bread wheat.

Conclusion:

The results showed that irrigation stop in sensitive growth stages of bread wheat varieties was ended in reduction at growth factors. In addition, reduction in more of growth factors was less in Alvand and Zarin varieties than Sayonz and Gaskozhen varieties. Actually, Alvand and Zarin varieties were the bestbread wheat varieties in Sanandaj region respectively and had the best adaptation with this region. Besides, normal irrigation had the best result in increasing of more of growth factors of bread wheat varieties. However, in drought stress conditions and water resources scarcity, we can have irrigation stop in heading or flowering or milk grain stages of bread wheat, without significant reduction in more of growth factors in comparison with normal irrigation.

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