Cercetări Agronomice în Moldova
Vol. XLVI , No. 1 (153) / 2013

EFFECTS OF IRON AND ZINC SPRAY ON YIELD AND YIELD COMPONENTS OF WHEAT (*TRITICUM AESTIVUM* L.*)* IN DROUGHT STRESS

F. MONJEZI[1], F. VAZIN[1]*, M. HASSANZADEHDELOUEI[1]

*E-mail: farshidvazin@gmail.com

Received October 5, 2012

ABSTRACT. In hot and arid regions, drought stress is considered as one of the main reasons for yield reduction. To study the effect of drought stress, iron and zinc spray on the yield and yield components of wheat, an experiment was carried out during the crop seasons of 2010 and 2011 on Shahid Salemi Farm in Ahwaz as a split factorial within randomized complete block design with three replications. The main plots with irrigation factor and three levels were considered: Level A) full irrigation, Level B) stopping irrigation at pollination step, and Level C) stopping irrigation at the seed filling stage. Subsidiary plots were considered with and without iron and zinc spray. Influencing the seed filling process, in interaction with iron, wich is an important leaf's chlorophyll cation, zinc increased the seed yield. The drought stress reduced the thousand kernels weight (TKW) and the number of seeds per spike increased about 24% and 8.5% more than the one of control treatment, respectively. Using iron, as compared with control treatment, causes the increase of thousand kernels weight from 45.71 to 46.83 grams and the increase of spike from 49.51 to 51.73. Zinc spray increased seed yield and thousand kernels weight. The results obtained from the present research showed that iron and zinc spray has fairly improved the effects caused by drought stress.

Key words: Drought stress; Iron; Spray; Zinc; Wheat.

INTRODUCTION

Drought is one of the factors, which threatens the agricultural products in most parts of the world (Abolhasani and Saeidi, 2004). Drought causes stress in plants. Not only it is resulted from precipitation reduction and hot temperatures, but also when the soil is moist, for some reasons such as high salinity of soil and/or soil frost, the moisture cannot be used by the plant and it causes stress in the plant (Baybordi, 2004; Soriano *et al.,* 2004).Drought and water shortage are considered as objective realities in Iran. In the past, water crisis has not been so serious as

[1] Islamic Azad University, Gonabad Branch, Gonabad, Iran

today; however, by increasing population during the past 100 years and becoming approximately six times bigger, the incidence of this crisis is more evident than before (Castro *et al.,* 2006; Goksoy *et al.,* 2004).

Under water shortage conditions, the effectiveness of fertilizers decreases, especially if consumption of these fertilizers is not compatible with the vegetative growth of plants. Among fertilizers, zinc sulfate fertilizer plays a more important role in adjusting stomata and ionic balance in plant system to decrease stresses caused by water shortage; therefore, under water shortage conditions, consumption of fertilizers should be balanced and optimized and special attentions should be taken to the consumption of zinc sulfate fertilizers (Karam *et al.,* 2007; Babaeian *et al.,* 2010). However, it should be noted that soils of Iran, which are categorized under the calcareous soils, due to drought stress, salinity, being calcareous, highly acidity, having low contents of organic materials, continuing drought, and continuing unbalanced consumption of fertilizers, iron and zinc contents are too low. Therefore, the plants which grow in such soils are mainly suffered from shortage of iron and zinc and shortage indications are observed in them (Jaleel *et al.,* 2009).

One of the most important effects, which accompany moisture, is that with the decrease of moisture in soil, movement of elements such as iron and zinc in soil solution decreases. This limits the growth of root and plants face additional shortage of this element (Chimenti *et al.,* 2002). It should be noted that plants, animals and humans need a little amounts of iron and zinc (Zhang *et al.,* 2006; Agele *et al.,* 2007). Jiang and Huang (2002) reported that the yield and its components in wheat are increased due to the effects of iron and zinc on the amount of chlorophyll and concentration of abscisic acid. The increase of chlorophyll increases yield through the increase of photosynthesis. Although plants need a little amount of zinc, if sufficient amount of this element is not available, plants suffer physiological stresses resulted from inefficiency of various enzyme systems and other metabolic functions related to zinc (Baydar and Erbas, 2005; Ehdaie *et al.,* 2008). Richards *et al.* (2002) reported that lack of zinc in microelements creates the major problems for producing crops, especially in soils of dry and semi-arid regions with shortage of water. Therefore, suitable usage of this element in dry and semi-arid regions is of crucial importance to improve the growth and yield of plants in these regions (Salehi *et al.,* 2004; Banks, 2004; Erdem *et al.,* 2006).

MATERIALS AND METHODS

This experiment was carried out in 2010 and 2011 in Shahid Salemi Research Farm in Ahwaz city. Ahwaz is located at the latitude of 31°20’ north, longitude of 48°40’ east and altitude of 18 meters above sea level. The average annual rainfall is 256 mm; the average annual temperature is 23°C with the annual relative humidity of 58%. Based on the climatic division, Ahwaz is of the dry and semi-arid regions. In this region, the evaporation to rainfall ratio is more than ten times. Before starting the experiment, in order to determine the physical and chemical properties of the soil, a sampling was carried out at five points of the experiment location from the depth of 0-30 and 30-60 cm. The soil texture was clay loam (clay 33%, silt 33.5% and sand 33%); pH and EC of soil were 7.95 and 11/48 EC*cm^{-1}, respectively. Available nitrogen, phosphorous and potash were 0.065%, 6.5% and 0.13%, respectively. The experiment was carried out as a split factorial with three repetitions. Drought stress was considered at the three levels of A) complete irrigation, stopping irrigation at the pollination stage, B) stopping irrigation at seed filling stage as the main factor. Iron and zinc spray, each at two spraying and non-spraying stages were considered as the subsidiary factors. Generally, there were 36 subsidiary plots with the surface area of 20 m^2 (5 meters NS and 4 meters WE) which were divided into two rows. The planted item was of Chamran type. Planting was performed on 23 November as dry planting with the density of 350 plants per square meter. According to the results obtained from the soil analysis, the required fertilizer was added to the farmland. To do so, 250 kg of urea, 150 kg of super phosphate and 100 kg of potassium soleplate per hectare were added to the soil. In order to calculate the seed yield, all the spikes picked from one square meter were distributed and threshed manually; at that moment, the humidity was about 14%. The biological yield (biomass) in each plot was performed after picking the plants from one square meter and counting all the spikes (number of spikes per surface unit). Five plants were selected randomly and the weight of thousand kernels and each spike, number of grains per spike, number of spikelets per spike, length of the spike, height of the plant and stem, diameter of the stem were calculated. Analyzing data and drawing graphs were carried out by SAS and EXCEL software. Comparisons of average related to the drought stress and spray were carried out through Duncan experiment.

RESULTS AND DISCUSSION

Seed yield

The results obtained from the analysis of data variances showed that the interaction between drought stress and elements spray on the seed yield is significant ($p < 0.01$) (*Table 1*). The highest seed yield from the simultaneous application of iron and zinc, under the stress-free condition and application of iron under the stress-free condition were 660.79 and 651.67 g*m^{-2}, respectively (*Fig. 1*). The lowest amount of iron application under the stressed condition at the seed filling stage and application of zinc under the stressed condition at the seed filling stage were 420.38 and 412.75 g*m^{-2}, respectively (*Fig. 1*). In all the stress treatments, except the stress at the flowering and stress-free stage, seed yield increased significantly by spraying iron (*Table 1*). In stress treatment at the seed filling stage, the increase was 10%. Apparently, seed yield increased due to the presence of iron, the increase of photosynthesis, and consequently the increase of efficiency of the dry substance. Yahyavi *et al.* (2004), showed that seed yield and percentage of protein increase significantly with the consumption of 5 mg of iron for each plant in one kilogram of soil. This result conforms to the ones obtained in the other studies (Banziger *et al.,* 2002; Chimenti *et al.,* 2002). Zinc spray increased the seed yield significantly in two stress treatments at the seed filling stage and stress-free condition (*Table 1*). The increase in stress treatment at the seed filling stage and stress-free condition were 12% and 14%, respectively. Zinc is an essential element, which is not consumed much. It takes part in all six classes of enzymes in plants (oxidoreductase, transferases, lyases, isomerase, hydrolases, and ligases); therefore, it plays a crucial role in the synthesis of proteins, carbohydrates, cell metabolism, protection of membrane from oxygen free radicals and other processes related to make the plants compatible with stresses (Yari *et al.,* 2005). Iron and zinc spray increased seed yield up to 10.4 % in comparison with the non-spray condition. Iron and zinc spray in stress treatments at seed filling stage and stress-free condition increased the seed yield significantly as 21% and 17%, respectively (*Table 1*); it also decreased the seed yield in the stress treatment at the flowering stage for 5 percent. Maximum decrease of the seed yield occurred at the seed filling stage. It appears that with the occurrence of drought at reproduction stages, seed filling stage period decreases which leads to weight loss of seeds. Drought stress reduces nutrient transfer from leaves to seeds as well. Drought accelerates ripening of seeds, this helps to reduce seed yield of grains through reducing photosynthesis (Baybordi, 2004).

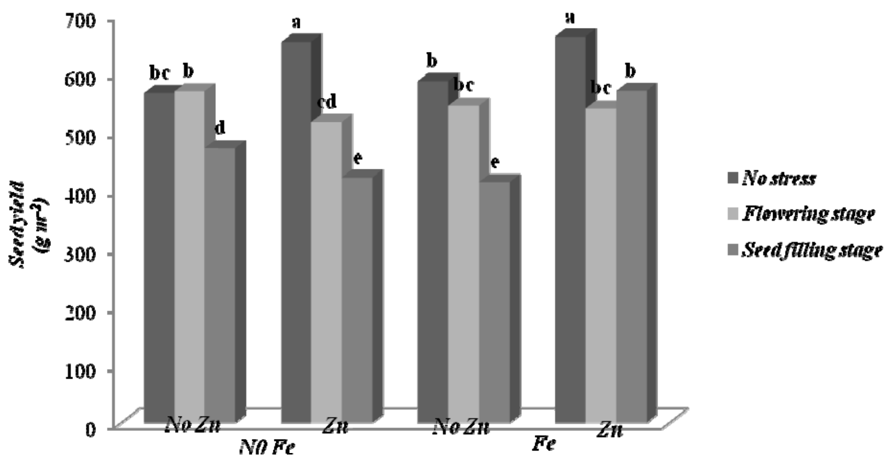

Figure 1 - Interaction drought stress, Zn and Fe on seed yield of wheat

Table 1 - Variance analysis and means compares of drought stress and Fe application on quality and quantity characteristics of wheat (*Triticum aestivum*)

Treatment	GY (gm^{-2})	BY (gm^{-2})	GN	1000 GW (g)	S_pN	SN	P (%)	PH (cm)	SD (cm)	SL (cm)
IRRIGATION										
I_{CON}	615.51 a	1529.32 a	55.87 a	49.33 a	19.57 a	569.00 a	12.00 c	99.52 a	2.75 a	12.59 a
I_{FLO}	540.73 ab	1421.21 b	44.90 c	45.13 a	17.37 b	529.90 a	13.30 b	96.80 a	2.73 a	9.02 b
I_{SFD}	168.04 b	1226.95 c	51.11 b	44.35 a	18.84 ab	475.00 b	15.00 a	97.93 a	2.64 a	10.80 ab
Fe RATE										
Fe_0	531.27 b	1349.44 b	49.51 b	45.71 a	18.14 b	511.50 b	13.02 b	97.08 a	2.71 a	10.22 b
Fe_1	551.57 a	1432.55 a	51.73 a	46.83 a	19.05 a	537.75 a	13.84 a	98.60 a	2.70 aa	11.38 a
Zn RATE										
Zn_0	523.74 b	1349.41	49.88 a	44.88 b	18.19 a	507.41 b	13.21 a	97.29 a	2.69 a	9.80 b
Zn_1	559.10 a	1435.56 a	51.37 a	47.66 a	19.00 a	541.83 a	13.66 a	98.40 a	2.72 a	11.81 a
SIGNIFICANT[1]										
Irrigation	*	**	**	ns	*	**	**	ns	ns	*
Fe rate	*	**	*	ns	*	**	**	ns	ns	*
Zn rate	**	**	ns	**	ns	**	ns	ns	ns	**
IxFe	**	*	**	**	**	*	**	*	*	**
IxZn	**	**	**	**	**	**	**	*	*	**
FexZn	**	*	**	**	*	**	**	ns	ns	**
IxFexZn	**	**	**	**	**	**	**	**	*	**

[1]Significant effects are denoted as: ns, *, **, non significant or significant at $P \leq 0.05$, 0.01, respectively.

I_{CON}: complete irrigation, **I_{FLO}**: stopping irrigation at the pollination stage, **I_{SFD}**: stopping irrigation at seed-filling stage. **Fe_0**: Without Fe, Fe_1: With Fe, **Zn_0**: Without Zn, Zn_1: With Zn. **GY**: Grain yield, **BY**: Biological yield, **GN**: Number of grain in plant, **1000 GW**: 1000 Grain weight, **S_pN**: Spikelet number, **SN**: Spike number, **P**: Percent of protein, **PH**: Plant height, **SD**: Stem diameter, **SL**: Spike length.

Yield components

Interaction of moisture stress and iron and zinc spray on yield components was significant ($p<0.01$) (*Table 1*). Applying iron and zinc at the same time under stress-free condition, the maximum weight of thousand kernels, number of grains per spike, number of spikelets per spike and number of spikes per surface unit were achieved. Under stress treatment at the flowering stage, iron spray increased number of spikelets per surface area, number of seeds per spikelet, and number of spikelet per spike significantly as 13.7%, 13.5% and 10.4%, respectively (*Table 1*). In all stress treatments, except stress at the seed filling stage, zinc spray increased yield components significantly (*Table 1*). In stress-free treatment, zinc spray increased number of spikes per surface area and thousand kernels weight as 10.5% and 15.9%, respectively. In stressed treatment at the flowering stage, zinc spray increased number of spikelets per surface area, number of spikelets in spike and number of seeds in spike as 16%, 10.8%, and 7.3%, respectively. Iron and zinc spray increased number of spikes per unit area, number of spikelets per spike, number of seeds per spikelet and thousand kernels weight significantly as 9.7%, 12.6%, 7.5%, and 8.8%, respectively as compared with non-spray (*Table 1*).

Biological yield

The interaction of drought stress and iron and zinc spray on the biological yield was significant ($p<0.01$) (*Table 1*). Simultaneous application of iron and zinc under stress-free conditions and application of iron under stress-free condition were 1593.08 and 1564.08 $g*m^{-2}$, respectively. Considering a statistical level and treatments of non-application of iron and zinc elements, under stress-free conditions at the seed filling stage and their individual application under the same stress condition, the maximum biological yield produced the least amount of biomass yield. Under the stress treatment at the seed filling stage, biological yield was increased significantly by spraying iron and zinc (*Table 1*). On iron spray, the increase (15%) was more than zinc (12.6%). Under stress-free conditions, iron and zinc spray significantly increased the biological yield for 13% (*Table 1*).

Protein

Drought stress has a significant effect - one percent probability - on the seed's percentage of protein (*Table 1*). The most percentage of protein was 15%, which was obtained in a stress treatment at the filling stage; the least percentage of protein was 12%, which was produced in a stress-free treatment (*Table 1*). Based on the obtained results, it seems that stress, at seed's filling stage, shortens the seed filling stage, which in turn, increases seed's protein, due to the increase of hydrocarbons contents. This result is consistent with other findings (Jiang *et al.,* 2002). Under the stress-free condition, iron spray increased the percentage of protein significantly (14.3%) (*Table 1*). Under the stressed condition at the flowering time, zinc spray decreased the percentage of protein significantly (6.5%) (*Table 1*). Percentage of protein placed significantly at the statistical level of one percent under the three-lateral interaction of drought, iron, and zinc interaction (*Table 1*). Simultaneous application of iron and zinc, under the drought stress condition at the seed's filling-stage with 15.16% and non-application treatment of iron and zinc, under the stress-free conditions with 10.70 % produced the maximum and the minimum seed's percentage of protein, respectively. Accordingly, when the seed-filling period is short, appropriate nutrition can increase seed's protein content and improve the quality of wheat grain.

CONCLUSIONS

As *Fig. 2* shows, when zinc element is not used, the relationship between number of seeds per spike and yield of seed is positive (R^2=0.33). With the increase of number of seeds, the yield of seed increases and vice versa; however, zinc spray decreases the effect of number of seeds on the seed yield (R^2=0.05). As *Fig. 3* shows, seed's weight importance is increased. As a result, if zinc spray is used, seed's weight importance will be increased as compared with the number of seeds in determining the yield seed. The trend of *Figs. 4 and 5* is fairly similar to the one of *Figs. 2 and 3*. The emphasis on the issue *"i.e. simultaneous use of iron and zinc has more effects on the relationships between the seed weight and seed yield than the time zinc is used only,"* means that iron could intensify the effects of zinc element. The use of iron and zinc spray, especially zinc element, can fairly compensate the decrease of yield caused by drought stress through increasing the seed weight.

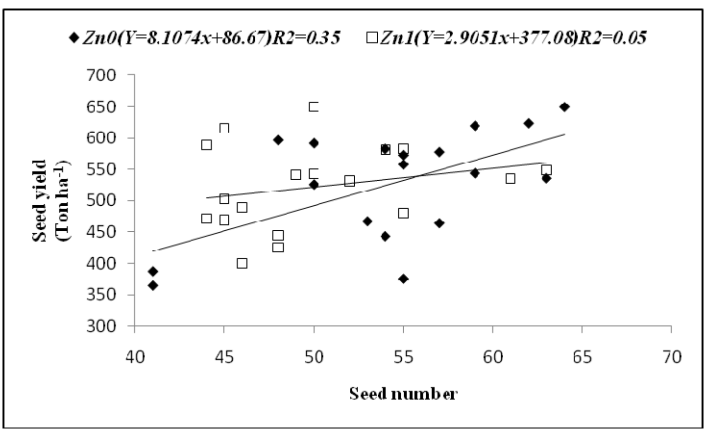

Figure 2 - Effect Zn on relationship between seed yield and seed number in panicle wheat

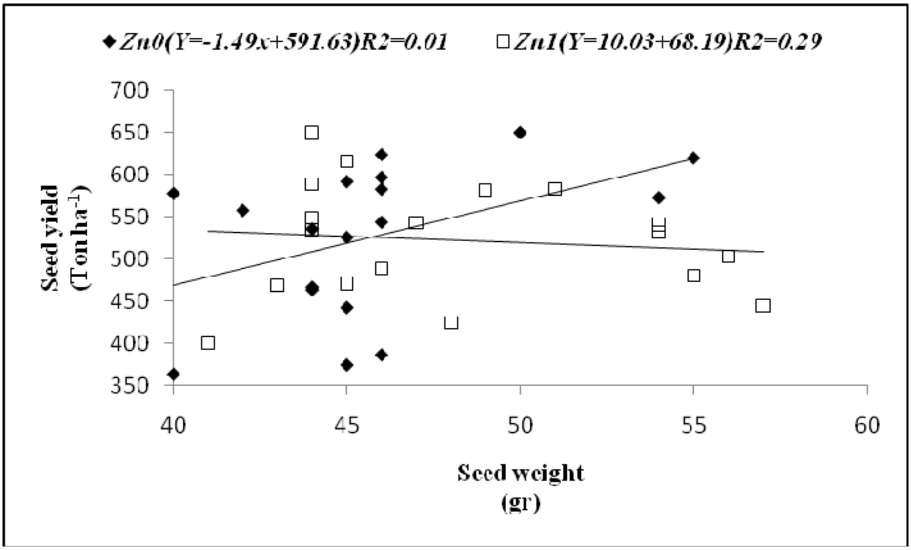

Figure 3 - Effect Zn on relationship between seed yield and seed weight in wheat

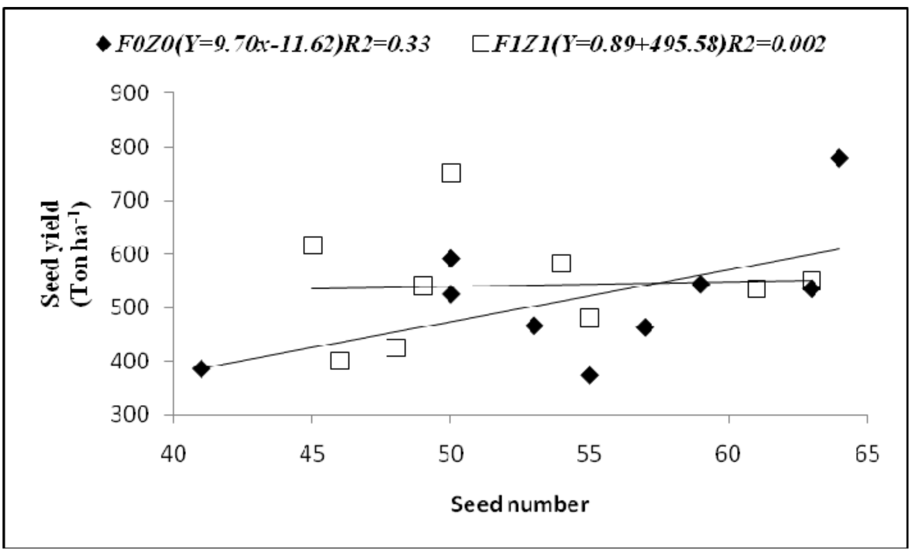

Figure 4 - Effect Zn and Fe on relationship between seed yield and seed number in panicle wheat

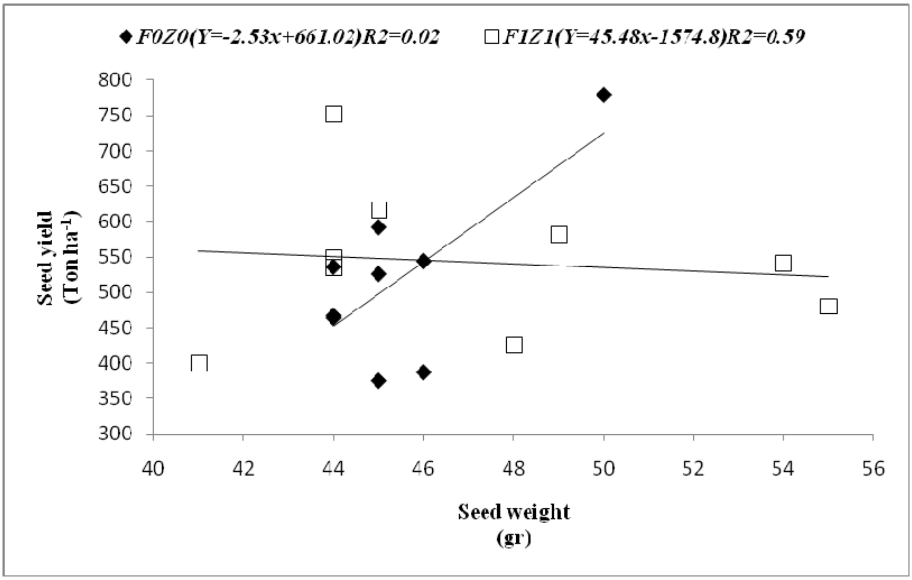

Figure 5 - Effect Zn and Fe on relationship between seed yield and seed weight in wheat

REFERENCES

Abolhasani K., Saeidi G., 2004 - Relationships between agronomic characteristic of safflower under water stress and control. Iran Journal Field Cops Research, No.1, pp.127-138.

Agele S.O., Maraiyesa I.O., Adeniji A., 2007 - Effects of variety seed set efficiency in late season sunflower *(Helianthus annus* L.) in a humid zone of Nigeria. Academic journals, No. 2, pp.80-88.

Babaeian M., Heidari M., Ghanbari A., 2010 - Effect of water stress and foliar micronutrient application on physiological characterstics and nutrient uptake in sunflower (*Helianthus annuus L.*). Iranian Journal of crop sciences, Vol.12, No.4, pp. 311-391.

Banks L.W., 2004 - Effect of liming of ofliar zinc fertilizer on yield component of soybeans. Australian journal of experimental agriculture and animal husbandry, Vol.22, No.1, pp. 226-231.

Banziger M., Edmeades G.O., Lafitte H.R., 2002 - Physiological mechanisms contributing to the increased N stress tolerance of tropical maize selected for drought tolerance. Field Crops Res., Vol 75, No.3, pp. 223-233.

Baybordi A., 2004 - Effect of Fe, Mn, Zn and Cu on the quality of wheat under salinity stress. Journal Water and soil Science, No. 17, pp.140-150.

Baydar H., Erbas S., 2005 - Influence of seed development and seed position on oil, faty acids and total tocophorol contents in sunflower (*Helianthus annuus* L.). Turkish Journal Agriculture, No. 29, pp.179-186.

Castro C.D.E., Moreira A., Oliveira R., Dechen A.R., 2006 - Boron and water stress on yield of sunflower. Ciencia Agrotecnologia, No. 2, pp. 214-220.

Chimenti C.A., Pearson J., Hall A.J., 2002 - Osmotic adjustment and yield maintenance under drought in sunflower. Field Crop Research., No.75, pp. 235-246.

Ehdaie B., Alloush G.A., Waines J.G., 2008 - Genotypic variation in linear rate of grain growth and contribution of stem reserves to grain yield in wheat. Field Crop Research., No.106, pp. 34-43.

Erdem T., Lokman D., Halim A., 2006 - Water use characteristics of sunflower under deficit irrigation. Pakistan Journal of Biological Science, No. 4, pp. 766-769.

Goksoy A., Demir T., Turan Z.M.H., Agustu N.D., 2004 - Responses of sunflower to full and limited irrigation at different growth stages. European Journal Agronomy, No.21, pp.117-127.

Jaleel C.A., Manivanannan P., Wahid A., Farooq M., H.J., Al-Juburi H.J., Somasundaram R., 2009 - Drought stress in plant: A review on morphological charactertise and pigments composition. International Journal Agriculture Biological, No.11, pp.100-105.

Jiang Y., Huang B., 2002 - Protein alterations in tall fescue in response to drought stress and abscisic acid. Crop Science, No.42, pp. 202-207.

Karam F., Lahoud R., Masaad R., 2007 - Evaporation, seed yield and water use efficiency of drip irrigated sun flower under full and deficit irrigation conditions. Agricultural water management, Vol. 90, No. 3, pp. 213- 235.

Richards R.A., Rebetzke G.J., Condon A.G., van Herwaarden A.F., 2002 - Breeding opportunities for increasing the efficiency of water use and crop yield in temperate cereals. Crop Science, No. 42, pp.111–121.

Salehi M., Koocheki A., Nassiri Mahalati M., 2004 - Leaf Nitrogen and Chlorophyll as indicators for salt stress in wheat. Journal Iran Field Crops Research, No. 2, pp. 25-33.

Soriano M.A., Orgaz F., Villalobos F.J., Fereres E., 2004 - Efficiency of water use of early plantings of sunflower. European Journal Agronomy, No. 21, pp. 465–476.

Yahyavi Tabriz S.H., Sadrabadi Haghighi R., 2004 - Effect of irrigation on yield and yield component of three spring canola cultivars under environmental of Tabriz. Iran Journal Field Crops Research, No.1, pp. 305-313.

Yari L., Modares M.A., Sorushzade A., 2005 - The effect of foliar application of Mn and Zn on qualitative characters in five spring safflower cultivars. Journal Water and Soil Science, No.18, pp.143-151.

Zhang M, Duan L, X.tian ZH, Li Z., 2006 - Unicanazole-induced tolerance of soybean to water deficit stress in relation to changes in photosynthesis, hormones and antioxidant system. Journal plant physiology, No.164, pp. 709-701.