Effect of drought stress and different planting dates on safflower yield and its components in Tabriz region

Afsoon Tayebi [1]*, Hossein Afshari [2], Farhad Farahvash [3], Jafar Masood Sinki [2] and Somayeh Nezarat[4]

1. MS student, Department of Agriculture, Damghan Branch, Islamic Azad University, Damghan, Iran
2. Department of Agriculture, Damghan Branch, Islamic Azad University, Damghan, Iran
3. Department of Agriculture, Tabriz Branch, Islamic Azad University, Tabriz, Iran
4. Agriculture Research Center of Shahrood, Iran

Abstract

In order to study the impact of drought stress and planting date on safflower yield and yield components, an experiment was performed in Tabriz region in 2011. The experiment was carried out as split-split plot based on randomized complete block design. The main factor which was applied as split plot includes drought stress with three levels: (S_1) 80 ± 3 mm evaporation from basin level of class A, (S_2) 120 ± 3 mm evaporation from basin level of class A, (S_3) 160 ± 3 mm evaporation from basin level of class A. The subsidiary factor studied in this research was studying 2 levels of planting date including (D_1): conventional planting date in region (date: 2011/4/19) and (D_2): 20days later from conventional planting date in region (Date: 2011/5/9). The sub-subsidiary factor was two different safflower cultivars include (V_1): Isfahan local cultivar and (V_2): Goldasht as modified cultivar. According to results the impact of drought stress on plant dry weight and leaf dry weight, plant height, number of branches and sub-shrubs, capitul in plant and seed in capitul as well as seed yield was significant. The effect of planting date on the traits being studied in this research was significant. The interaction of drought stress and planting date, except in dry weight of leaf, was not significant in other traits.

Keywords: drought stress; planting date; safflower; yield

Tayebi, A., H. Afshari, F. Farahvash, J. Masood Sinki and **S.Nezarat.** 2012. 'Effect of drought stress and different planting dates on safflower yield and its components in Tabriz region'. *Iranian Journal of Plant Physiology* 2 (3), 445 – 453.

Introduction

The oilseeds are known as enormous resources of energy and protein. Not only these plants have an essential and crucial role in human and animal nutrition but also the circulation of industrial and economic wheels of several countries depend on them. According to increasing demand of country for edible oils, development of cultivation of oilseeds is very important. Among oilseeds compatible with country's conditions, safflower as a plant resistant to drought and salinity stress and having to types of spring and fall has a promising future. Safflower yield, as other agricultural products, is influenced by different factors such as genotype, planting date, compression, humidity and soil fertility, temperature and light.

Plants are constantly affected by environmental signals. Each factor which stops or

*Corresponding author
E-mail address: aafsoontayebi@yahoo.com
Received: May, 2012
Accepted: June, 2012

restrains the normal metabolic process of a plant is considered as stress. Some of these stresses, such as drought stress limit the growth in plants. Drought stress is one of the most important environmental stresses which, in many regions of world , especially dry and warm regions , cause the crops yield to be limited. Irrigation through changing the yield components may affect the yield. The effect of appearance time of drought stress on the seed yield may be as important as stress intensity (Zue et al., 2005). Drought stress in germination stage of safflower causes the reduction of percentage and rate of germination (Mostafavi, 2011). Drought stress in vegetation stage, by reducing leaf area index, causes decrease in dry matter production and decrease in plant yield. Istanbulluoglu (2009) announced that different irrigation regimes in safflower in rapid growth of stem, flowering and aggregation stages, cause the seed yield has significant increase and the most sensitive stage in safflower which needs water is flowering and filling stage. Nabipour(2007), showed that different irrigation regimes had a significant effects on the seed, the crude oil yields , seed number per boll, harvest index, total dry weight.

The planting date is the first central point in management decisions for crop production, especially in regions which have environmental constrains such as late or early cold at the beginning and end of season and intense heat of mid-summer. The plant yield has a direct relationship with length of growth period. One of the reasons for yield decrease in delayed planting date, is the decrease in length of growth period through acceleration of maturation time. Mirzakhani et al. (2002) noted in their research that traits such as number of sub-shrubs per plant, number of capitul per plant, number of seeds per capitul and plant height had a significant decrease in the delayed planting date than the first planting date. They concluded number of sub-shrubs, number of capitul per plant, number of seed per capitul, percentage of cold damage and seed yield that affected by different planting dates, became significant. Some thought that existence of more sub-shrubs in plants which were cultivated earlier, was related to longer duration of Rosette period, so that in this period, due to very slow growth, plant begins to produce nascence branch and on the other hand, the relative coolness of weather in time of fast growth of plant, provide appropriate conditions for producing sub-shrubs.

It was reported in a research that the number of days from cultivation to emergence, and from emergence to stem elongation was decreased with delay in cultivation. Also time to 50% of flowering and from 50% of flowering to physiological maturity, with delay in cultivation, at first decreased and then increased (Heydarizadeh et al., 2008). In this study, temperature was mentioned as the most important factor in decreasing the length of this period.

Bagheri et al. (2006) declared that the safflower plant height was also influenced by the planting date. It was observed that delay in planting date may cause decrease in plant height by increase in temperature and length of day which caused the decrease of vegetation growth rate and plant height. Also, the planting date, by changing other factors such as moisture available in soil, may affect the plant height.

So in order to increase the exploitation of environmental facilities for increasing the crop production, it is necessary to pay attention to historical background of plants cultivation in regions and their compatibility with special environmental conditions. This research was done with purpose of studying the impacts of planting date and drought stress in Tabriz climatic conditions on growth and yield of safflower. As amount of result is too much, we omission cultivars effect in results of this article.

Materials and Methods

This experiment was established in 2011 at research farm of Tabriz Azad University located in Karkaj land in 15 Km east of Tabriz.

The experiment was done as split-split plot based on randomized complete block design with three replications. The main factor which was applied as split plot includes drought stress factor with three levels with evaporation from basin level of class A: (S_1) 80 ± 3 mm, (S_2) 120 ± 3 mm and (S_3) 160 ± 3 mm. The irrigation factors were applied after establishment of plant until end of physiological maturity of cultivars. The first irrigation treatment was affiant or non-stress condition. The second irrigation treatment (medium stress) and third irrigation treatment (high stress) were selected for studying the impact of lack of water in soil on growth , yield and yield components of safflower proportion to different amounts of water.

The subsidiary factor studied in this research was studying 2 levels of planting date including D_1: conventional planting date in region (date: 2011/4/19) and D_2: 20days later from conventional planting date in region (date: 2011/5/9). The sub-subsidiary factor was studying the cultivar in two levels: V_1: Isfahan local cultivar and V_2: Goldasht as modified cultivar.

The appropriate planting time of safflower was specified according to the weather conditions of Tabriz.

Chemical control of weeds in safflower farm was done by using pre-implantation herbicides such as Trifluralin and Eptam. Each experimental plot had 5 m length, and 5-rows were prepared with row width and intra-row space of 50 and 10 cm, respectively. In order to avoid interference, a non-planting row was placed between main plots. Based on soil analysis in this study, any fertilizer was not used. Plants in end of growing period were harvested from a $4m^2$ area in order to measure the final yield and yield components. Measurements included number of branches and sub-shrubs, dry weight of leaf and plant, plant height, number of seeds per capitul, number of capitul per plant, weight of 1000 seeds, and number of hollow seed. In order to measure dry weight of leaves and plants, the samples were put in the oven with 75 ˚C for 48 hours separately. The analysis of variance of data was done by MSTATC and SAS software and for comparing the means, Duncan test was applied in probability level of 5%.

Result

Plant dry weight

Drought stress had a significant effect on amount of dry weight of safflower (Table 1). Results showed that applying drought stress causes significant reduction in dry weight of safflower plant (Table 2). The highest mean of plant dry weight was observed in S_1 level (80mm evaporation) with amount of 97.92 gr in plant. The effect of planting date on plant dry weight was significant ($P<0.01$) and two selected planting date had a significant difference (Table 3). Plant dry weight in conventional planting date was greater in comparison with the later planting date.

Table 1
Analysis of variance for selected characteristics, seed yield and yield components of safflower

		Means square									
S.O.V	d.f	Seed Yield	No. hollow seed	No. seed per capitul	No.Capitul Per plant	No. sub-shrub	No. branch	1000 seed weight	Plant height	Leaf dry weight	Plant dry weight
Block	2	866297.7	79.45	10.08	0.46	0.38	2.61	1.44	142.35	21.19	183.99
S (stress)	2	10608585.1*	302.10ns	1614.96*	7.72*	40.16*	8.50*	298.22ns	954.08*	250.77**	267.96**
Error (block* S)	4	1152424.5	78.80	204.88	0.80	4.43	1.05	162.57	134.32	8.66	6.18
D (date of planting)	1	10802176**	318.58*	1690.58**	98.34**	204.49**	45.33**	1163.9*	8302.24**	766.36**	3177.9**
DS	2	9602116ns	52.50ns	156.20*	8.34ns	13.08ns	0.08ns	195.3ns	149.34ns	105.50*	4.71ns
Error D (block D* S)	6	317612	35.57	25.94	4.35	4.21	1.66	65	97.87	19.61	49.26
V (variety)	1	1769023.4*	485.00**	1816.18**	104.38**	294.69**	6.41*	899**	4804.80**	412.76**	454.82*
SV	2	618571.3ns	18.88ns	248.68ns	2.49ns	9.23ns	0.65ns	88.88ns	257.73*	66.03ns	97.23ns
DV	1	5081ns	1.20ns	34.61ns	51.60**	22.09*	2.15ns	199.2*	216.58ns	159.18*	59.70ns
SVD	2	340307.2ns	2.84ns	317.99ns	8.25*	12.89ns	1.33ns	11.6ns	195.30ns	251.54*	71.07ns
Error V (remained)	12	219857	20.79	97.95	1.91	3.88	1.03	31	56.23	30.28	81.28
(C.V%)		15	24	17	14	25	19	13	10	15	10

**,* Significant at 0.01 and 0.05 probability levels, respectively; ns: Not significant (p>0.05)

Table 2
Comparison of the means of selected characteristics, seed yield, and yield components as affected by drought stress

Treatment	Plant dry weight (gr/plant)	Leaf dry weight (gr/plant)	Plant height (cm)	1000 seed weight (gr)	No. sub-shrubs	No. branches	No. capitul/plant	No. seed/capitul	No. hollow seed	Seed yield ($Kg.ha^{-1}$)
80 mm evaporation	97.92a	40.79a	79.75a	45.49	9.78a	6.20a	10.22a	67.33a	13.58	3871.1a
120 mm evaporation	89.64b	32.44b	61.92b	40.27	6.18b	4.55b	9.63ab	54.84ab	19.24	3110.8ab
160 mm evaporation	89.82b	33.39b	70.80ab	35.52	7.41ab	5.08ab	8.65ab	44.05b	23.59	2002.2b

Values within the same column followed by the same letter(s) are not significantly different according to Duncan (p=0.05)

Table 3
Comparison of the means of selected characteristics, seed yield, and yield components as affected by planting date

Treatment	Plant dry weight (gr/plant)	Leaf dry weight (gr/plant)	Plant height (cm)	1000 seed weight (gr)	No. Sub-shrubs	No. branches	No. capitul/plant	No. seed/capitul	No. hollow seed	Seed yield ($Kg.ha^{-1}$)
Conventional planting date	101.86	40.15	86.01	4.61	10.17	6.4	11.16	62.22	15.83	3544.4
Delayed planting date	83.06	30.92	55.64	3.47	5.41	4.1	7.86	48.52	21.78	2448

Values within the same column followed by the same letter(s) are not significantly different according to Duncan (p=0.05)

Leaf dry weight

Analysis of variance obtained from Table 1 showed that, leaf dry weight was significantly influenced by the drought stress ($P<0.01$). Drought stress caused the significant decrease in the leaf dry weight. Comparison of the means showed that the highest amount of leaf dry weight was observed in the 80 mm evaporation from basin level of class A. There was no significant difference between two other drought stress levels (Table 2). Water shortage and occurrence of drought stress in growth environment of safflower caused a decrease in plant size, change in leaf color, reduction in the durability of leaves, and even decrease of yield (Kafi and Rostami, 2008).Therefore, in drought stress conditions, with reduction in size and leaf area, leaf weight will also decrease. According to the results shown in Table 1, the effect of planting date on leaf dry weight was significant ($P<0.01$). The conventional planting date caused 29% increase in leaf dry weight, compared with the delayed planting date treatment (Table 3). As Table 1 suggests, interactions between different levels of drought stress and planting date had significant effect on leaf dry weight ($P<0.05$). With delay in planting date and increase in level of drought stress, the leaf dry weight showed a decreasing trend. The most pronounced dry weight decrease was observed in the conventional planting date and 80 mm evaporation from basin level of class A (S_1) measuring 45.96 gr (Table 4).

Plant height

Plant height was reduced significantly under drought stress ($P<0.05$). The highest mean of plant height was observed in 80 mm evaporation from basin level of class A (S_1) measuring 79.75 cm (Table 2). Statistical analysis of the data from two planting dates in this experiment showed a significant difference ($P<0.01$) (Table 1). Results showed that the highest plant height was observed in the conventional planting date measuring 86.01 cm (Table 3). Delay in planting date caused 64% decrease in plant height in comparison with the conventional planting date.

1000 seed weight

Effect of drought stress on weight of one thousand seeds was not significant statistically (Table 1). The studies showed that there is a significant difference between the different

Table 4
Interaction of drought stress and planting date on Safflower traits

Treatment		Plant dry weight (gr/plant)	Leaf dry weight (gr/plant)	Plant height (cm)	1000 seed weight (gr)	No. sub-shrubs	No. branches	No. capitul per plant	No. Seed Per capitul	No. hollow seed	Seed yield ($Kg.ha^{-1}$)
80 mm evaporation	1st planting date	107.02	45.9a	98.55	52.71	12.86	7.26	11.80	75.11	11.46	4480.5
	2nd planting date	88.81	35.6bc	60.96	38.26	6.70	5.13	8.70	59.35	15.70	3261.6
120 mm evaporation	1st planting date	98.61	39.7b	76.95	41.38	9.06	5.76	12.16	57.68	17.80	3355.9
	2nd planting date	80.68	25.1d	46.90	39.16	3.30	3.33	7.10	52.00	20.68	2877.5
160 mm evaporation	1st planting date	99.94	34.8bc	82.55	44.25	8.60	6.16	9.53	53.88	18.23	2796.9
	2nd planting date	79.71	31.9c	59.06	26.80	6.23	4.00	7.78	34.21	28.94	1207.4

Values within the same column followed by the same letter(s) are not significantly different according to Duncan (p=0.05).

planting dates in terms of their effect on 1000 seed weight. The maximum weight of one thousand seeds was achieved in the conventional planting measuring 40.61 gr (Table 3). The interaction of drought stress and planting date was not significant on 1000 seed weight (Table 1).

Number of branch

The findings showed that the drought stress had a significant effect on the number of branches (Table 1). As Table 2 suggests, the greatest number of branches was observed in the 80 mm evaporation from basin level of class A (S_1) and the less was achieved from 120 mm evaporation from basin level of class A (S_2). Results also showed that the effect of planting date on the number of branches was significant ($P<0.01$). The mean in conventional planting date was 6.4 while in the delayed planting date, it was 4.15 (Table 3). It can therefore be concluded that delay in planting caused a decrease in the number of branches.

Number of sub-shrub

In this research, drought stress had a significant effect on the number of sub-shrubs ($P<0.05$). The drought stress caused a significant decrease in this trait (Table 2). The maximum number of sub-shrubs was observed from 80 mm evaporation from basin level of class A (S_1) and the minimum number was observed in treatment of 120 mm evaporation. The effect of delay in planting date on the number of sub-shrubs was significant ($P<0.01$). With delay in planting date, the number of sub-shrubs in safflower decreased (Table 3). The mean number of sub-shrubs in the conventional planting date in the region was 10.17 while in the delayed planting it was 5.41.

Capitul per plant

Number of capituls per plant was influenced by drought stress and it was significant at probability level 0.05 (Table 1). Drought stress significantly decreased the number of capituls in safflower plant. Comparison of the means showed that safflower plants in control level (80 mm evaporation) and 160 mm evaporation respectively had the maximum and minimum number of capituls per plant (Table 2).

The planting date had significant effect on the number of capituls per plant ($P<0.01$). With delay in planting date, less number of capituls were formed in the plants (Table 3). In this study the maximum number of capituls per plant was obtained in planting date around mid May, with mean 5.9 capituls per plant. Statistical analysis showed that the interaction of drought stress and planting date was not significant (Table 1).

Seed per capitul

Experimental results showed that, the drought stress had significant effect on the number of seeds per capitul ($P<0.05$). It is inferred from mean comparisons, that applying drought stress caused significant decrease in the number of seeds per capitul (Table 2). The maximum number of seeds per capitul was observed in 80 mm evaporation from basin level of class A (S_1) with mean of 67.33. The minimum number of seed per capitul on the other hand was observed in stress level of 160 mm evaporation with measuring 44.05 on the average.

The analysis of variance showed that the impact of planting date on the number of seeds per capitul was significant ($P<0.01$). Similarly, delay in planting date caused the number of seeds to decrease making a significant difference in comparison with conditions of conventional planting date (Table 3). The mean number of seeds per plant in the conventional planting date and the delayed planting date were 62.22 and 48.52, respectively.

Number of hollow seeds

According to results of this experiment, the effect of drought stress on percent of hollowness of seeds was not significant (Table 1). The planting date has a significant effect on the percent of hollowness of seed trait ($P<0.05$). Comparisons of the means showed that delay in planting dates led to the production of more hollow seeds (Table 3). Percent of hollowness of seeds in the conventional planting date was 15.73%.

Seed yield

Table 1 shows the analysis variance of experimental factor on safflower seed yield. As it may be seen in Table 1, the seed yield was significantly influenced by drought stress ($P<0.05$). In this study, the maximum yield was observed in 80 mm evaporation from basin level of class A (S_1) with 3871.1 $Kg.ha^{-1}$ and the minimum yield was observed in treatment of 160 mm evaporation with 2002.2 $Kg.ha^{-1}$ (Table2).

The results showed that seed yield was significantly influenced by different planting dates (Table 1). The amount of safflower yield in plants which treated with delayed plantation decreased significantly in comparison with the conventional planting date in the region (Table 3). Seed yields in conventional and delayed planting date were 3544.4 and 2448 $Kg.ha^{-1}$, respectively. In this study, interaction between drought stress and planting date on seed yield of safflower was not significant (Table 3).

Discussion

Experimental results showed that plant dry weight decreased with drought stress. Tahmasebizadeh et al. (2008) observed that the dry weight of plant and maximum accumulation of dry weight in the first planting date (20th of May) was greater in comparison with later planting dates. They noted that the plants grown later than the specified time, due to high temperature, gained the required GDD for Rosette stage very quickly, and without having any proper supply of growth, enter the linear growth stage, which eventually leads to reduction of total dry weight of the plant. But in the proper planting date, plant produce maximum leaf area, may absorb the maximum solar radiation and their performance of radiation absorbance increases. Lack of water and occurrence of drought stress in growth environment of safflower led to a decrease in plant size, change in leaf color, cut down the durability of leaf and eventually, reduction of yield (Kafi and Rostami, 2008). Therefore, with reduction in size and leaf area under drought stress conditions, leaf weight will decrease too.

Results showed that plant height decreased under drought stress. It has been specified that drought stress decreases the height, through reducing the growth rate of the plant and the closer time of applying stress is to the late stages of growth season, the less impact stress has on plant height (Rostami, 2004). It seems that shorter height of plants, in drought stress condition, leads to the reduction in seed yield.

Results of this experiment revealed that changing in planting date can influence plant traits. The results of Omidi and Sharif Moghadas (2010) showed that the plant height was significantly decreased by late planting date. The planting date may be affecting the growth and height of plant, through changes in environmental conditions such as temperature, length of day, and moisture available in soil during the growth season. Bagheri et al. (2006) reported that the plant height significantly reduced with delay in planting date. He contended that this could be attributed to the increase in temperature and length of day which shortened the duration of the vegetative period and therefore, decreased the growth and plant height. It was reported in another experiment that the 1000 seeds weight of safflower was influenced by the planting date (Tahmasebizadeh et al., 2008). Results showed that yield component was influenced by experimental factors. Some main factors in decreasing the number of fertile capituls are lack of water, high temperature, decrease in photosynthetic materials and prematurity. Moosafar et al. (2009) noted in their research that cutting irrigation had a significant effect and decreased the number of capitul per plant. It seems that any factor that influences plant growth, e.g. irrigation, will cause formation of more potential places for producing capitul on plant, through increasing the height, sub-shrubs and growth period (Behdani and Jami Alahmadi, 2009). Other researchers have observed the decrease in number of capitul per plant in reaction to decrease in water level (Kafi and Rostami , 2008).

Tahmasebizadeh et al. (2008) declared that the number of capituls in safflower plant was influenced significantly by planting date. Cutting irrigation in pollination stage, leads to infertility of pollen and disorder in current photosynthesis and transfer of stored material to seeds which will cause a decrease in the number of seeds in drought stress. Pasban-Eslam (2011) has studied the drought stress impact on the number of seeds per capitul and reported that drought stress caused a significant decrease this trait.

Decrease in the length of growth period due to delay in planting and smaller plants along with smaller capituls, decreased the number of seeds per capitul. Tahmasebi et al. (2008) reported that number of seeds per capitul was influenced by planting date and with shortening of growth period, the number of seeds per capitul decreased. Mazaheri et al. (2005) reported that percent of hollowness is one of the traits of crops which is influenced by environmental factors and activity of pollinator insects and delay in planting caused increase in this trait. The increase in percent of hollowness of seed due to delay in planting date, maybe related to increase in temperature, and facing of flowering and pollination periods with high temperature and high evaporation and transpiration. The reason is that in such conditions, the activity of pollinator insects is limited and pollens dry under high temperature and low humidity conditions and their fertility decreases.

The decrease in seed yield in limited irrigation conditions may be related to effect of water shortage due to irrigation cutting, which is along with acceleration of senescence and decrease in the growth period and filling of plant seed as well as transmitted signs from root to leaf and inducing the stomatal closure and eventually decrease in pure photosynthesis (Clavel et al., 2005). Koutroubas et al. (2005) thought that the decrease in seed yield under drought stress conditions could be due to the inaccessibility of plants to irrigation water, which as a result, increased plants competition for water and decreased their number of capituls per plant, number of seeds per tray and weight of one thousand seeds and increased the percent of hollowness of tray which had significant and positive correlation with seed yield. These results are consistent with studies of Zahedi et al. (2008). It was specified in this study that higher seed yield in more irrigation treatment may be related to production of more leaves, stems and sub-shrubs in the plant.

Yau (2006) reported that delay in planting dates in semi-dry regions decreased seed yield since last flowers were not able to survive the heat and drought at the end of the season. Omidi and Sharif Moghadas (2010) noted that the effect of cultivar and planting date was significant on the plant yield.

In general, the results of this study showed that drought stress decreased safflower yield and its components. In this study, stress had less effect on the 1000 seeds weight and decreased safflower seed yield through decrease in the number of seeds per capitul, number of capitul per plant, and number of branches and sub-shrubs. According to the findings, observing factors such as appropriate planting date may cause more seed yield through increase in length of growth period, more favorable weather conditions, less competitive power of weeds, less damage of pests and diseases, and more appropriate temperature in each growth stages, especially pollination stage. In the experimentation region, April 19th was more appropriate planting date than the second planting date on May 5th. Because of high tolerance of safflower against drought, in comparison with other crops, it may be a valuable crop for the environmental conditions of the region, but it is necessary to plant it in the first possible opportunity so that unfavorable environmental conditions may not constrain its production potentials.

References

Bagheri, H., R. Saeedi and **E. Zaeh.** 2006. 'Evaluation of agronomic traits of selected genotypes from safflower mass native in the spring and summer planting'. *Agricultural Technology and Sciences and Natural Resources* 10: 375-390.

Behdani, M. A. and **M. Jami Al-Ahmadi.** 2008. 'Evaluation of growth and yield safflower cultivars in different planting dates'. *Iran. Agron. Res.* 6(2), 245-254. (In Persian with English summary).

Clavel, D., N. K., Drame, H., Roy-Macauley, S., Braconnier and **D., Laffray,** 2005.' Analysis of early responses to drought associated with field drought adaptation in four sahelian groundnuts (*Arachis hypogaea* L.) cultivars'. *Environ. Exp. Bot.* 54: 219-230.

Koutroubas, S. D., D. K. Papadoska, and **A. Doitsinis.** 2005. 'Cultivar and Seasonal effects on the contribution of pre-anthesis assimilates to safflower yield'. *Field Crops Research*, 90:263-274.

Mazaheri laghab H., A. Moradi and **H. Sepehri,.** 2005 . 'Assessing the effect of planting pattern and date on performance of sunflower armavirski cultivar (*Heliantuhus annuus*) in Marivan'. *Research and development in agriculture and horticulture*, 69: 31-39.

Mirzakhani, M., M. Ardakani, A. Shirani Rad and **Abbasi Far.** 2002 . 'Effects of planting date on performance and performance components of spring safflower cultivars in the Markazi'. *Iranian Crop Science Journal*, 4: 138-150.

Mostafavi, K. 2011. 'An evaluation of safflower genotypes (*Carthamus tinctorius* L.), seed germination and seedling characters in salt stress conditions'. *African. J. Agri.l Res.* 6(7):1667-1672.

Mousavi Far, B. Behdani, J. Al-Ahmad, M. Hosseini Bajd. 2009. 'Effect of cutting irrigation at different stages of reproductive growth on performance, performance components and spring safflower three cultivars oil'. *Journal of Agricultural Ecology*, 1:51-41.

Nabipour M, M. Meskarbashee and **H. Yousefpour.** 2007. 'The effect of water deficit on yield and yield components of safflower (*Carthamus tinctorius* L.)'. *Pak J Biol Sci*. 10(3):421-426.

Omidi A. H. and M. R. Sharifmogadas. 2010. 'Evaluation of Iranian safflower cultivars reaction to different sowing dates and plant densities'. *World Applied Sciences Journal*, 8 (8): 953-958.

Pasban-Eslam, B. 2011. 'Evaluation of physiological indices for improving water deficit tolerance in spring safflower'. *J. Agr. Sci. Tech*. 13: 327-338.

Rostami, M. 2007. 'Effects of drought stress on performance, performance components and percentage of safflower cultivars oil in irrigation conditions with saltwater'. *Research Journal of Iranian Agricultural* 1: 121-132.

Tahmasebizadeh, H., N. Khodabandeh, L. Madani and **A. Farahani** 2008 . 'Surveying the analysis of spring safflower growth and its effect on the performance in Weathers conditions of Arak. *The new Findings Agriculture* 3 (2): 136-154.

Yau, S. K. 2006. 'Winter versus spring sowing of rain-fed safflower in a semi-arid, high elevation mediterranean environment'. *Europ. J. Agronomy* 26: 249-256.

Zahedi, M., B. Mamqany, M. Mesgar Bashi, M. Kashani, A. S. Montaseri. 2008 . 'Surveying the effects of planting date and watering treatments on physiological indicators of spring safflower two cultivars'. *The new Findings Agriculture* 2 (3): 239-252.

Zhu ,X., H. Gong, G. Chen , S. Wang and **C. Zhang.** 2005. 'Different solute levels in two spring wheat cultivars induced by progressive field water stress at different development stage'. *J. Arid. Environ.* 62:1-16.