Contents lists available at GrowingScience

Management Science Letters

homepage: www.GrowingScience.com/msl

Effect of drought stress and plant density on yield, component yield and content oil of Safflower in province of Zanjan, Iran

SepidehTarighi[a*], Khalil Jamshidi[b], AfshinTavakoli[b] and **Mohammad Reza Azimi Moghadam[b]**

[a]*MSc, Department of Agronomy and Plant breeding , Faculty of Agriculture , Zanjan University*
[b]*Assistant Professors , Department of Agronomy and Plant breeding , Faculty of Agriculture , Zanjan University*

A R T I C L E I N F O

Article history:
Received March 18, 2012
Received in Revised form
April, 20, 2012
Accepted 28 May 2012
Available online
June 2 2012

Keywords:
Number of capitula in plant
Number of grain in capitula
1000 seed weight Domestic

A B S T R A C T

This paper studies the effect of drought stress and plant density on yield, component yield and content oil of Safflower. The paper conducts an experiment spilt block in the form of randomized complete block design in three replications at the research farm of agriculture college of Zanjan university in the year 2009. The main factor includes four levels of drought stress, which are normal, cut of one time irrigating before flowering, cut of one time irrigating after flowering, cut of one time irrigating in grain filling stage and sub plot including three-level plant density (200, 300, 400 thousands plant per each hectare). The results of experiment showed that biologic yield, seed yield, component yield and oil yield in different levels of drought stress and plant density were significantly different. The greatest biologic yield and seed yield were for treat cut of one time irrigating before flowering and treat 200 thousand bushes per each hectare. The highest seed yield and oil yield getting for treat normal and after that for treat cut of one time irrigating in grain filling stage.

1. Introduction

According to Ashraf (2010), drought is one of the prime abiotic stresses in the world and crop yield losses due to drought stress are significant. Although different approaches have been used to alleviate the problem of drought, plant breeding, either conventional breeding or genetic engineering, seems to be an economical tools of tailoring crops to enable them to grow effectively in drought-prone environments.

Istanbulluoglu et al. (2009) performed a survey to detect the impacts of water stress imposed at various development stages on grain yield, seasonal evapotranspiration, crop–water relationships, yield response to water and water use efficiency of safflower (Carthamus tinctorius L.) for winter and summer sowing. The field trials were performed on a loam Entisol soil in Thrace Region in Turkey, using Dincer, the most well-known safflower variety in the research area. The highest total water use efficiency was achieved in the treatment irrigated only at vegetative stage while the lowest value was

* Corresponding author. Tel: +989127424173
E-mail addresses: sepideh_tarighi@yahoo.com (S.Tarighi)

doi: 10.5267/j.msl.2012.06.001

found when the crop was irrigated only at yield stage. They concluded that winter sowing is a better approach, if deficit irrigation is to apply at only one or two stages, Y stage or Y and F stages should be omitted, respectively.

Movahhedy-Dehnavy et al. (2009) reported that there are some significant relationships between different traits in safflower. They also reported that foliar Zn and Mn application could improve the seed yield and seed quality of safflower grown under drought stress. Kaya et al. (2006) performed an investigation to determine factors responsible for germination and early seedling growth due to salt toxicity or osmotic impact and to optimize the best priming treatment for these stress conditions. The results disclosed that germination delayed in both solutions, having variable germination with various priming treatments. According to Kaya et al. (2006) Germination, root and shoot length were higher but mean germination time and abnormal germination percentage were lower in NaCl than PEG at the same water potential. Dordas and Sioulas (2008) reported based on a comprehensive study that N fertilization could influence yield, yield components, photosynthetic efficiency, and physiology of safflower under rainfed conditions.

Koutroubas and Papakosta (2010) explained that Safflower plants grown under Mediterranean environments, which experience several biotic and abiotic stresses during the seed filling period, which limit their production. They investigated the genotypic and seasonal variation in seed filling parameters and their association with agronomic traits in field experiments conducted for 2 years.

Dschaak et al. (2010) evauated productive performance of dairy cows fed changing levels of whole Nutrasaff safflower seed, a new variety of safflower seed, and identified its impact on milk fat content and milk fatty acid composition. Koutroubas et al. (2009) studied the impacts of phenotypic variation in physiological traits on development and yield of spring sown safflower under Mediterranean conditions. They reported that spring sown safflower could be considered as an alternative rainfed crop in cool Mediterranean areas where winter kill is a problem.

2. The proposed model

Experiments were accomplished in a farm during spring season in province of Zanjan, Iran. The weather conditions are cold and dry mostly surrounded by mountains and the average precipitation is 293.5 millimeters and it starts from November and it continuous until the mid spring. In order to study effect of drought stress and plant density on yield, component yield and content oil of Safflower, conducted an experiment split block in the form of randomized complete block design in three replications at the research farm of agriculture college of Zanjan university in the year 2009.

The land becomes suitable by three different operations including plough, surfacing and segmentation. We have distributed 200 kilogram Urea per hectare in forms of strip before cultivating on trees. We have cultivated 20, 30 and 40 plants in the areas of 5, 6.5 and 10 centimeters. All weeds were removed manually during the stages of budding, we have used pesticide materials to protect the cultivated plants.

The main factor including four levels of drought stress, which are normal, cut of one time irrigating before flowering, cut of one time irrigating after flowering, cut of one time irrigating in grain filling stage. It also includes sub plot including three levels plant density, which are 200, 300, 400 thousand plants per each hectare. Each experimental Crete consists of five seven-meter rows and in each row has a distance of 50 cm from the each other.

We have investigated the growth trend during the season of growth and started our job 50 days after the growth was started and each 15 days the sampling was repeated. During the sampling, we cut 35 cm from the beginning and the end of samples and they were immediately to laboratory, transferred. All samples were kept in $70^{\circ c}$ for 48 hours and after they were dried we measured the weights of all samples very carefully. The data were analyzed using MSTATC and Excel software packages.

3. The results

A comprehensive study on Safflower has indicated that drought stress effect and plant density had meaningful biological impact when the significance level is one percent. Treat normal with an average of 10753.5 kg in the highest hectare and treat normal irrigation before flowering with an average of 7098.3 kg per hectare produced the lowest amount of dry material. Drought stress before flowering 33.99% and stress after flowering 20.67% and stress while seed during the filled process 13.68% reduced biological performance. However, the results of comparing averages indicate that the effects of stress were not the same during the growing process on reducing biological performance. When there is no stress, longer durability of leaves create enough biological resources to use more light, which leads to increase the amount of dry materials. The effect of plant density on biological performance was meaningful when the level of significance was one percent so that when plant density increases from 20 to 40 per square meter, biological performance was increased for about 16.83%.

Table 1
The results of biological performance, component yield and content oil of Safflower in different levels of drought stress and plant densities

Source of changes	Df***	Plant height	Oil yield	Harvest index	Biological performance
Replication	2	ns 2.8	ns1.136	ns7.6	ns2085422.1
Drought stress	3	543.57*	158462.7**	21.5*	62470152.5*
Error	6	6.23	392.2	3.76	270325.9
Plant density	2	46.54*	17552.9**	5.2ns	6578009.5**
Error	4	4.27	175.5	3.1	285755.8
Compression stress	6	2.87ns	3609.4ns	8.05ns	127800.7ns
Error	12	2.78	405.7	7.9	185441
Coefficient of changes	%C.V	12.46	5.75	17.5	17.34

ns: Not significant, *meaningful with significance level of 1 percent, ** meaningful with significance level of 5 percent, ***degree of freedom

Table 2
The results of biological performance, harvest index, oil yield and plant height in different levels of drought stress and plant densities

Treat	Biological performance (kg/hectare)	Harvest index (%)	Oil yield (kg/hectare)	Plant height (cm)
Drought stress				
Natural	10753.5a	17.63a	484.3a	77.52a
Before flowering	7098.3d(33.9%)	13.96c	183.3d	58.95c
After flowering	8529.9c(20.67%)	16.25ab(7.82%)	309.6c	65.16b
Seeding stage	9281.5b(13.68%)	16.58ab(5.95%)	423.3b	59.04b
Plant density per hectare				
400,000 plants	8770.4a	16.79a	386.1a	69.50a
300,000 plants	8123.8b	16.05a	354.3b	67.91a
200,000 plants	7293.5c	15.48a	309.9c	65.59b

*Percentage of parameters compared with natural

3.1. Grain performance

Based on the results of Table 3, the effects of levels of stress when the level of significance is one percent and the effects of different levels of plant density when the level of significance is five percents are meaningful. In addition, the results of comparing averages indicate that natural treatment with average production of 1455.62 kg/hectare maintains the highest grain yield. The lowest grain performance is associated with treatments under stress before flowering stage, which was a reduction of 36.21% one performance of grain compared with natural (Table 4). The average stress treatment when grains are growing and stress treatment after flowering are 1349.63 and 1178.73 per hectare, respectively. As the number of plants increase in each square meter, the number of grains per capitula reduces but it seems that the increase in the number of capitula in each square meter, which is the results of increase in plant density, can compensate this reduction.

Table 3
The results of biological performance, seed yields, the number of capitula per plants, the number of grains per capitula and grain in different levels of drought stress and plant densities

Source of changes	Df***	Seed yield	The number of capitula per plant	The number of grains in capitula	Grain
Replication	2	26638.9ns	4.2ns	1073.4ns	0.1ns
Drought stress	3	2034969**	197.8*	45473.9**	70.3**
Error	6	11600.3	1.8	950.1	0.09
Plant density	2	257769.6*	23.3*	8108.3*	15.8ns
Error	4	17617.8	2.03	641.9	0.32
Compression stress	6	ns16386.5	1.1ns	214.7 ns	3.5ns
Error	12	32148.9	1.4	368.4	0.13
Coefficient of changes	%C.V	13.57	19.93	11.29	7.02

ns: Not significant, *meaningful with significance level of 1 percent, ** meaningful with significance level of 5 percent, ***degree of freedom

Table 4
The results of biological performance, grain yields, the number of capitula per plants, the number of grains per capitula and seed in different levels of drought stress and plant densities

Treat	Grain	The number of capitula per plant	The number of grains in capitula	seed yield
Drought stress				
Before flowering	928.21 (36.21%)*	7.05d	91.49d	36.35b (4.16%)*
After flowering	1178.73c	10.17c	140.49c	35.23b
Seeding stage	1349.63b	13.16b	189.77b	31.37c
Plant density per hectare				
400,000 plants	1406.16a	10.79b	141.26b	34.02a
300,000 plants	1322.57b	11.99a	176.54b	35.32a
200,000 plants	1173.06c	13.57a	191.97a	36.31a

*Percentage of parameters compared with natural

3.2 Harvest index

This index is a kind of yields from transportation of photosynthesis materials produced in plant to grain. Based on the results of Table 1, we realize that the effects of different levels of stress are meaningful on this index when the level of significance is one percent. The highest value of this index in natural treatment is 17.63% and the lowest value is associated with stress treatment before flowering, which is 13.96%. The harvest of index after stress treatment is 16.25%, which is 7.82% less than natural treatment. Stress treatment in stage of growing seed represents a 5.95% reduction in harvest index, which shows lower changes compared with other stages and these results are summarized in Table 2. Note that the effect of plant density on harvest index was not meaningful as shown in Table 1.

3.3 Number of capitula in plant

The results of Table 3 on safflower show that the effect of drought stress and plant density on the number of capitula in plant is meaningful when the level of significance is one percent. The maximum and the minimum number of grains in plants in natural treatment and stress before flowering are 18.07 and 7.05, respectively. Stress treatment during the growth time of seeds and stress after flowering are on lower position compared with natural treatment and the results are given in Table 4. The effect of plant on the number of capitula in plant is meaningful when the level of significant is one percent (Table 3). The lowest number of capitula in plant belongs to 400000 plants per hectare (Table 4). In most cases, when we increase the number of plants in each area, the number of capitula in plants is reduced.

3.4. Number of seeds in capitula

Based on the results of Table 3, the effect of drought stress is meaningful when the level of significance is one percent and the effect of plant density on the number capitula on plants is meaningful when the significance level is five percent. Treatment cut of irrigation before flowering maintains 91.49, which is the lowest amount (Table 4). The shortage of required water in different stages on growth and drought stress in safflower reduces the number of capitula. The effect of plant density on the number of grain on capitula is meaningful when the level of significance is five percent (Table 3). The number of capitula in plant is 141.26, which is the lowest number of seeds when the density is 400,000 (Table 4). When density of plant increases, the number of seeds and the number of capitula are reduced.

3.5.Weight of one thousand seeds

The impact of stress on one thousand seeds is meaningful when the level of significant is one percent (Table 3). In stress treatment before flowering, we realize that the weight of one thousand grains is reduced by 4.16 percent and there is not a meaningful difference between stress before and after seeding growth. Natural treatment with an average of 37.93 gram maintains the highest weight of one thousand seeds (Table 4). The effect of plant density on one thousand grains is not meaningful (Table 3).

3.6. Oil yield

According to the results of Table 1, the effect of stress and plant density on the performance of oil is meaningful when the level of significance is one percent. This shows the meaningful impact of irrigation stress on reduction of oil yield of safflower. The performance of oil in natural treatment with 484.33 kg per hectare is superior to stress treatment. Stress treatment before flowering is 183.34 kg per hectare and it has the minimum performance of oil (Table 2). This is probably because the performance of oil has a bad impact of stress on the weight of grain and as a result, it has a bad impact on oil yield per hectare. As the plant density increases from 20 40 plants per square meter, oil yield is increased for about 19.72 percent and this increase is due to increase in seed performance.

3.7. Plant height

The impact of stress and plant density on plant height is meaningful when the level of significance is five percent (Table 1). The highest height belongs to natural treatment with an average of 77.52 cm and the lowest height belongs to stress treatment before flowering with an average of 58.95 cm (Table 2).

4. Conclusion

The results of our study have indicated that safflower has different reaction on different soil conditions in terms of the level of moisture and it has high genetic capability to adapt itself to environment. The highest performance of grain and oil belongs to natural treatment and the lowest performance belongs to stress treatment before flowering, which indicates the highest compatibility to environment. When the density of plant is 40 per square meter, the highest grain performance have been achieved compared with two other densities. In summary, we can conclude when this kind of plant is cultivated, it is important to select appropriate distance between different grains.

Acknowledgement

The authors would like to thank the anonymous referees for their constructive comment on earlier version of this work.

References

Ashraf, M. (2010). Inducing drought tolerance in plants: Recent advances. *Biotechnology Advances*, 28(1), 169-183.

Dschaak, C.M., Eun, J.S., Young, A.J., & Bergman, J.W. (2010). Nutritive merits of whole Nutrasaff safflower seed when fed to Holstein dairy cows during midlactation. *Animal Feed Science and Technology*, 156(1-2), 26-36

Dordas, C.A., & Sioulas, C. (2008). Safflower yield, chlorophyll content, photosynthesis, and water use efficiency response to nitrogen fertilization under rainfed conditions. *Industrial Crops and Products*, 27(1), 75-85

Istanbulluoglu, A., Gocmen, E., Gezer, E., Pasa, C., & Konukcu, F. (2009). Effects of water stress at different development stages on yield and water productivity of winter and summer safflower (Carthamus tinctorius L.). *Agricultural Water Management*, 96(10), 1429-1434.

Kaya, M.D., Okçu, G., Atak, M., Çıkılı, Y., & Kolsarıcı, Ö. (2006). Seed treatments to overcome salt and drought stress during germination in sunflower (Helianthus annuus L.). *European Journal of Agronomy*, 24(4), 291-295

Koutroubas, S.D., & Papakosta, D.K. (2010). Seed filling patterns of safflower: Genotypic and seasonal variations and association with other agronomic traits. *Industrial Crops and Products*, 31(1), 71-76.

Koutroubas, S.D., Papakosta, D.K., & Doitsinis, A. (2009). Phenotypic variation in physiological determinants of yield in spring sown safflower under Mediterranean conditions. *Field Crops Research*, 112(2-3), 199-204

Movahhedy-Dehnavy, M., Modarres-Sanavy, S.A.M., & Mokhtassi-Bidgoli, A. (2009). Foliar application of zinc and manganese improves seed yield and quality of safflower (Carthamus tinctorius L.) grown under water deficit stress. *Industrial Crops and Products*, 30(1), 82-92