Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Annals of Biological Research, 2013, 4 (1):183-189
(http://scholarsresearchlibrary.com/archive.html)

Annals of Biological Research
Scholars Research Library
ISSN 0976-1233
CODEN (USA): ABRNBW

Effect of Water Stress on the Amount of Seed Oil in Different Lines of Safflower(*Carthamus tinctorius* L.)

Mahboobeh Rajab Nasab Agha mahali[1] and Jirair Carapetian[2]

[1]M.S. graduate in plant science from Urmia University
[2]Department of Biology, Urmia University, Iran

ABSTRACT

In order to investigate the effect of water stress (primary factor) on the amount of seed oil in different lines (secondary factor) of cultivated safflower (Carthamus tinctorius L.), an experiment was performed in the experimental farm of Urmia University. The safflower lines under investigation consisted of four winter types (697, Zarghan 279, LRV51-51 and LRV51-279) and one spring type Esfahan-1. Seeds of the above five lines were planted each in two rows with four replications during spring season. The experimental design used for the winter types was a split plot and a completely randomized design was used for the spring type. Water stress levels were applied in the form of increasing the days between irrigations beginning with plot A towards plot D at flowering time which consisted of four treatments for the four plots A, B, C and D. Data analysis for the amount of oil in winter types indicated that water stress level C had the highest effect on the increase of seed oil. On the other hand the line 697 had the highest overall seed oil among the entries. The highest interaction was recorded for the line 697 in the A plot (check) having 35.55% seed oil. In the one way analysis of variance for the seed oil in the spring type plot B was considered as check. The interaction between winter type × stress resulted in a decrease in oil content, however, in the Spring types, water stress caused an increase in oil content. These contrasting results were due to genetic differences between spring and winter types and the meteorological specificity of the experimental site.

Key Words: cultivated safflower, oil content, seed, water stress.

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is a plant of the Compositae family which is cultivated mainly for its seed as a source of edible oil or to be used as birdseed. In the past, safflower was being cultivated for its flowers as a source of dye for textile and as a source of medicine, although this latter use is still in effect. Safflower seed oil having a high level of linolenic acid has a precious medicinal effect for people with high blood pressure and coronary heart disease [17]. Safflower oil has a purgative effect and when used as rubbing oil is effective for the cure of rheumatism and paralysis [19]. Safflower has a strong taproot which renders the plant resistant under dry climatic conditions. A fully mature safflower seed from a common variety consists of 30-60% seed coat and 40-67% of pulp. The amount of seed oil ranges between 20 and 45 percent and sometimes higher[3]. The major safflower growing countries are India, Mexico and USA and the first two grow about 70% of the world production [8].

In Iran, safflower is grown in Khorasan, Yazd, Esfahan and Azerbaijan provinces and in some areas its growth encounters such unfavorable conditions as drought and salt stress [5].Various factors, among them water stress exert

their effect on yield and seed quality of safflower. It has been have that the amount of oil in line S-144 is 2% higher than line 7-13-3 under similar water regime and the former line is more tolerant to water stress [20]. work on irrigation methods in safflower has shown that the variety Gila and lines C2517 and VFSTP have the highest tolerance to water stress [4]. It has been shown that the increase in the frequency of irrigation results in an increase in seed oil percentage in several varieties and lines except for the lines 894 and S208 [7].

In an experiment on the effect of irrigation on safflower line JSF1 in plot irrigations including non-irrigated plots, irrigation before planting (BS), +BS at bloom time and seed filling period and the application of various amounts of nitrogen (0, 30, 60 and 90kg/ha). It has shown a 31% increase in yield as compared with non-irrigated plots for the BS treatment, while the highest oil percentage was observed during the +BS, flowering and seed filling periods [11]. Experiment on safflower has shown that the application of one irrigation (10 cm water) before planting, 6 cm water irrigated at branching period, 5 cm water irrigated at bloom time for the N10 variety, the highest yield was obtained when watered at bloom time when the highest amount of water was also consumed [13]. In an experiment on the effect of water shortage on safflower lipids have shown that an intermediate stress caused an increase in total lipids but a severe stress results in a rapid decrease in lipid content [6].

work on the effect of water regimes in safflower line Kuseh, PI and IL111 have shown that water stress reduces seed oil content and that an appropriate water regime can enhance the quality of seed oil [2]. work on the effect of the amount of irrigation water and its salinity on various lines namely local 2811, Bhima, Acetaria, 241, N133 and V51-4209 has reported the observation of a significant difference at 1% level between the lines [5]. studying the botanical and morphological characteristics of a safflower collection under Fall planting has reported that in the line LRV51-51, the seed yield has been 2010 kg/ha with 28.9% oil and a total of 582 kg oil/ha [12]. In this experiment the seed oil percentage in lines 697, Zarghan 279 and Esfahan-1 has been 26.68, 25.01 and 30.49 percent, respectively.

In another study on the effects of water stress on seed oil content in three safflower selections, namely, LRV51-51, Zarghan 279 and Varamin 295, have shown that water stress treatments have had no significant effect on the seed oil content [15]. In a different study of water stress in safflower, there are some reports about minor and non-significant effect on oil content [9]. It has been shown that various levels of water stress reduces seed oil content as compared with the check, however, no significant differences was observed between the stress levels [10]. water stress has no significant effect on seed oil content in spring type safflower lines [16]. The main use for safflower oil is in culinary, as salad oil, and the industrial preparation of margarine. In addition, because of its semi-dry characteristics, safflower oil was being used in the past in the preparation of paints [1].

Due to the importance of safflower oil and considering the effect of irrigation in various growing phases of the plant on seed yield and oil quality, this experiment was performed to elucidate the effects of water stress on seed oil content on safflower lines, namely, 697, Zarghan 279, LRV51-51, LRV51-279 and Esfahan-1 under our climatic conditions.

MATERIALS AND METHODS

The specifications of safflower lines under study based on a report from Karaj Experimental Station is shown in table1.

Table1: The specifications of safflower lines under study based on a report from Karaj Experimental Station.

Safflower lines	Flower color	Spininess	Days from planting to maturity
LRV51-51	Orange	Spiny	299
Zarghan 279	Red	Spiny	300
697	Orange	Spiny	299
LRV51 295*	---	---	---
Esfahan-1	Orange	Spineless	101

* *this line was missing from Karaj studies*

A plot of land measuring 200 square meters with sandy-clay soil and a pH=7 was ploughed twice and prepared for planting in May. The experimental plots were prepared for winter type lines using a split plot design and for the Spring type using a completely randomized design. The main plots were designated as A, B, C and D and each plot contained the five lines of safflower under investigation. Each line was planted on two adjacent rows 5 m long and

60 cm apart and these five lines were planted with 110 cm distance between them to avoid any water leaching among them during irrigation. Therefore, each plot consisted of ten rows from the five lines of safflower, namely, 697, Zarghan 279, LRV51-51, LRV51-279 and Esfahan-1. Water stress was applied at four different levels. In order to prevent water logging and to avoid the expansion of phytophtora root rot, raised beds were prepared for seeding. Watering was performed in furrows between the two rows for each line. The winter type seeds were received from Kermanshah Agricultural Experiment Station and the spring type seed was received from the Center for Oilseed Research in Tehran.

A germination test was initially performed on the received seed samples using ten seeds from each line after their dusting with a fungicide in a petri dish at 25^{oC} in an oven. Good germination result was obtained after 4-5 days. From each safflower line, 400 g of seed, after dusting with a fungicide, was used for planting the experiment in May. Seeds were planted 4-5 cm deep and the experimental field was irrigated on the following day. During the plant growth period, weeds were hand removed in several occasions which was essential for obtaining dependable results from the experiment. Six weeks after planting, the emerged seedlings were thinned in each row to ensure their optimum and uniform growth. Two months after planting, a complete nutrient solution was sprayed on all safflower seedlings. Using different chemical sprays, namely diazinon, dinocap and topsin, various insects and fungal diseases were kept under control. The experimental field was uniformly irrigated as required until the time when water stress was established.

Based on reports by [11-13], as safflower plants are highly vulnerable to irrigation for root rot diseases before flowering time, therefore, water stress treatments were begun after the completion of branching period and at the beginning of flowering time. As the spring type safflower has a shorter growing period compared to Winter types, flower initiation was observed three weeks earlier in the Spring type line. Using a ten year meteorological data for the experimental site, it was decided for the plots A, B, C and D to apply irrigation once every 5, 8, 11 and 14 days, respectively, for the Spring type and once every 8, 11, 14 and 17 days, respectively, for the Winter types. In the meantime, for Spring safflower, the B plot was considered as check which was based on the observed wilting symptoms. The check plot for Winter type rows was the A plot.

The amount of water applied to each twin row was under control by a water meter at 300 liters for each irrigation period. Due to cooling of the weather towards the end of growing season, the volume of water applied was reduced to 250 liters. In addition, the irrigation cycles were increased uniformly for all rows by five days. One month after the final irrigation, plants were mature enough for harvest. At harvest time, each twin row was subdivided into four longitudinal parts and seed harvest was performed from each part separately and was considered as one replication. Seed samples were kept for two days at 50^{oC} for uniform drying. Each sample was ground separately with an electric grinder.

The Soxhelet method using a mixture of chloroform and methanol (2:1) was used for oil extraction using a 5 g sample [18]. Oil extraction was carried out from each sample for 4.5 hrs. A rotary evaporator was used for solvent evaporation and the purification of oil from each sample. The amount of oil in each sample was calculated on a percentage basis. An appropriate analysis of variance was carried out to determine treatment significance and for the comparison of means.

RESULTS AND DISCUSSION

Comparison of means for the seed oil percentage among the four stress levels in Winter type safflower lines indicated that the highest oil percentage of 30.33 belongs to stress level C which was significantly different from stress levels A and B but not different from D at 1% level of significance (Fig. 1).This result is in accordance with results obtained by [6], in which a medium level of water stress resulted in an increase in seed oil percentage.

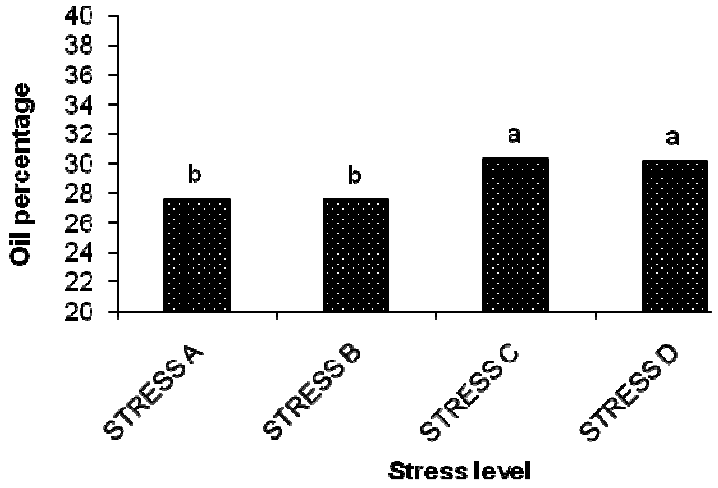

Fig. 1. Average seed oil percentage in Winter type safflower under different levels of water stress.

Mean comparisons among Winter type safflower lines using Duncan's multiple range test indicated that line 697 contained the highest level of seed oil percentage which was significantly higher than the other lines at 1% level of significance (Fig. 2).

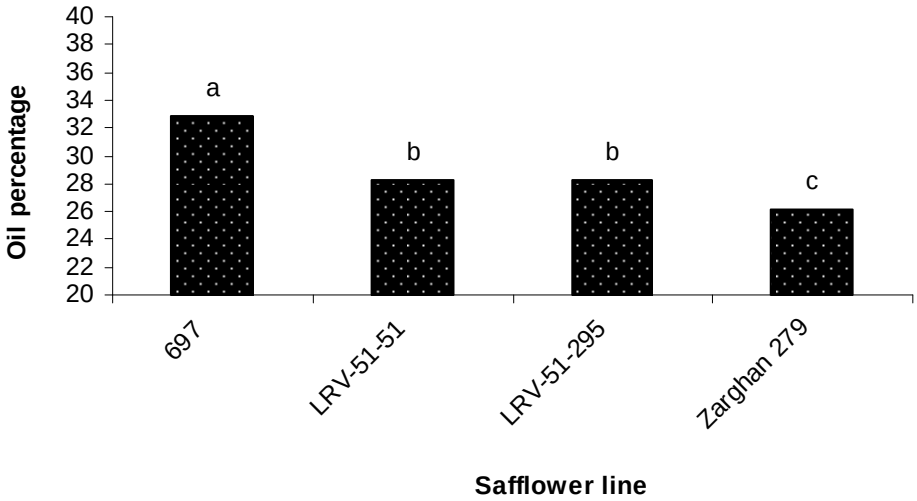

Fig. 2. Average seed oil percentage in various lines of Winter type safflower.

In the studies by [20], the safflower line S-144 contained the highest seed oil percentage and in the studies by [4] on safflower variety Gila and lines C2517 and VFSTP, some lines had a better tolerance to water stress. Hence, in our studies, line 697 can be suggested for planting under the situation of dry and low water availability conditions. In our data analysis when both factors of water stress as the primary factor and line as the secondary factor was analyzed together, the following results were obtained. Mean oil percentages among lines in stress level A showed that line 697 had the highest seed oil of 35.55% which was significantly different from the other lines (Fig. 3A). Similar results was obtained under stress level B in which line 697 again had the highest seed oil percentage. However, it was significantly different at 1% level of significance only when compared with the line Zarghan 279 (Fig. 3B). Under the stress level C, also, the highest seed oil percentage of 33.30 was recorded for line 697 which was significantly different from the other three lines (Fig. 3C). Again, when data analysis was performed for stress

level D, it was observed that line 697 had the highest seed oil percentage which was significantly higher than the other lines except for the line LRV51-51 (Fig. 3D).

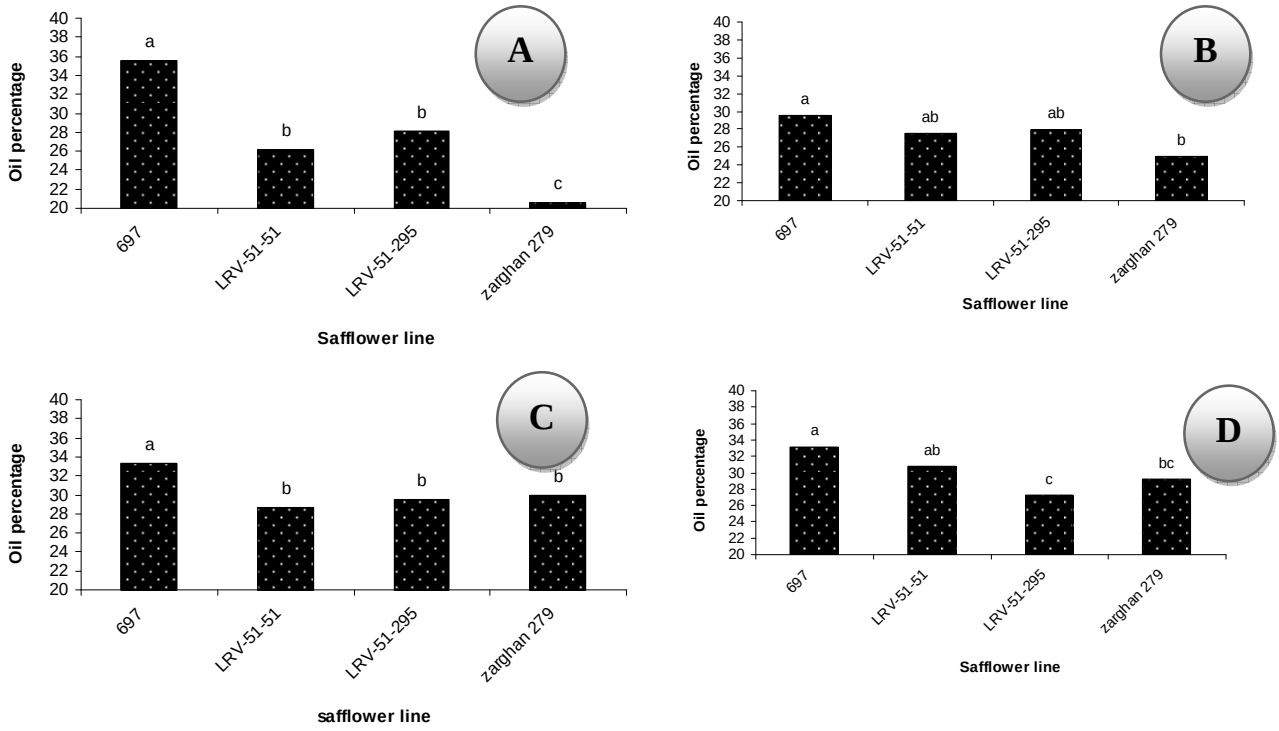

Fig. 3. Average seed oil percentage among Winter type lines of safflower under water stress levels A, B, C and D

Fig. 4 depicts the results of overall analysis of variance of the seed oil in the four winter type safflower lines over the four water stress levels. As can be seen, line 697 has shown the highest seed oil content (35.55%) in stress level A which is significantly higher than the other combination of line x stress levels except for the same line in stress levels C and D. Hence, it can be deduced that similar to results obtained by [2]. water stress results in a general reduction in seed oil content. Studies by [5], is in confirmation of results obtained in our study. In contrast, some other reports such as [7-10-15], indicate that water stress has no significant effect on the level of seed oil. It appears that these contrasting results is due to variation in environmental conditions, differences in safflower line characteristics and the severity of water stress applied in these studies.

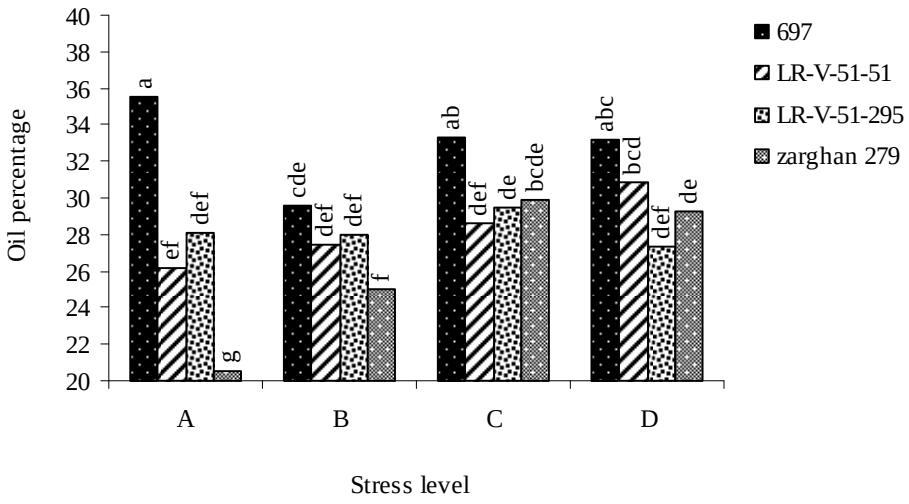

Fig. 4. Comparison of mean seed oil percentage among lines of Winter type Safflower under four water stress levels.

Analysis of results obtained from the seed oil of the Spring type safflower Esfahan-1 indicated that under the most severe stress level (D), the oil percentage was increased to a level of 43.20% which when compared with the check (stress level B), was 6.40% higher and its difference was statistically significant (fig.5). In a study of water stress test by [16] on Spring type safflower, no statistically significant differences were obtained between the stress levels under investigation. Hence althouth it is a general belief that drought stress basically decreases safflower seed oil level in sensitive phonological stages [21], our results with line Esfahan-1shows a reverse situation. It appears that the main reason is due to the fact that Esfahan-1 is a selected line for growing under the dry conditions of Esfahan province in iran. Therefore, genetic differences between safflower lines due to their breeding background can play a major role in the obtained experimental results in each area. It can be concluded that both factors of line characteristics and water regime should be taken into account in order to be able to enhance the seed oil level of safflower.

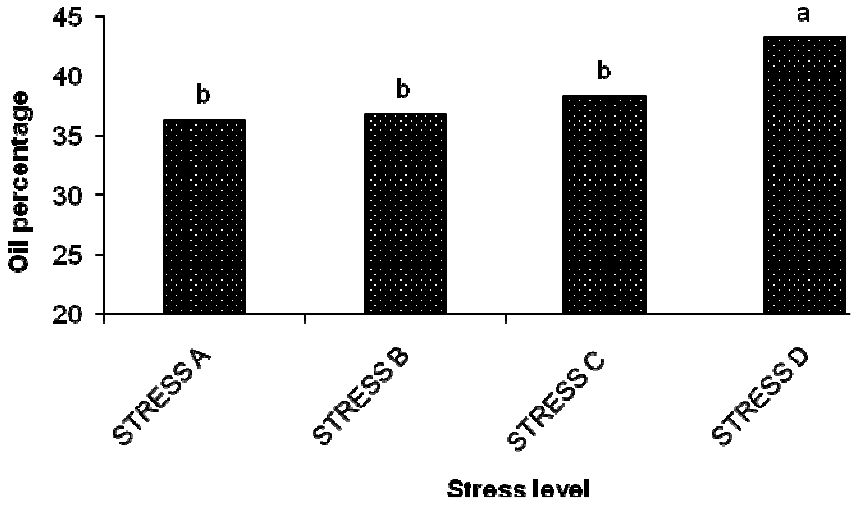

Fig. 5. Mean seed oil percentage in the Spring type safflower line Esfahan-1 as effected by different water stress regimes.

CONCLUSION

Contrasting oil content results were due to genetic differences between Spring and Winter types and the meteorological specificity of the experimental site. Hence increasing the period of irrigation affected seed oil percentage for Winter and Spring types of safflower diffrently. Although increasing the period of irrigation on Spring type safflower was more effective increasing seed oil percentage as compared with the Winter types of safflower.

Acknowledgements
We thank the genetic laboratory at the university of Urmia who provided facilities for experiments and final data analysis. We also thank Dr.Nojavan and Dr. khayami for their generous helps.

REFERENCES

[1] Anonymous, Growing safflower. Oilseed crop research and development company Iran,**1972**, 2nd. Ed, pp.1-35.
[2] E Ashraf, Kh Ramzani. *JAOCS*, **2010**, 499-506.
[3] L Dajue, H mündel. *IPGRI*, **1996**, pp 83.
[4] Dj Davia. *Agronomy abstract*, **1977**, 97-98.
[5] K Foroozan. *Indian J Agron*, **1997**, 38 (1), 150 - 151.
[6] I Hamrouni, HB Salah, B Marzouk. *Phytochemistry*, **2001**, 58(2), 277-80.
[7] AN Hang, DW Evans. *Agronomy – Journal*, **1985**, 77 (4), 588 - 592.
[8] A Mater, A Johnson. Marketing - serie - natural - resources – Institute(NRI), **1993**, No. 6, 26 pp. Chatham, Uk.
[9] MR.Naderi Darbaghshahi, E Bani Taba, MR Shahsavari, H R.Javanmard. *Research in agricultural science*, **2007**, 2, 138-150.
[10] MR Naderi, Gh Noormohhamadi, A Majid, F Darvish, A H.Shirani Rad, H Madani. *Sapling and Seed*, **2004**, Vol. 20, No. 3.
[11] PM Nimje. Indian J Agron, **1991**, 36 (supplement), 165 - 168.
[12] A. Omidi, Karaj agricultural research center. oil crops section Iran, **1996**.
[13] SN.Prasad, B Verma, C Parkash, R Singh. *Indian J Agr Sci*, **1992**,62 (4), 254 - 257.
[14] N Saadat Lajvardi, **1980**, Oilseed crops. Tehran university press.
[15] E Syrusmehr, MR Shakiba, H Aliari, M.Toorchi, E Dabbagh Mohhamadinasab. Agricaltural Knowledge, **2007**, 17 (1), 69-82.
[16] M Tavoosi, MS thesis in Agronomy. Islamic Azad University, Khorasgan unit. Khorasgan, Iran, **2007**.
[17] W Gurong, W Zhamu, Xinming, C Yuehua. Study on food medicine made from safflower seed oil, **1997**, IVth international safflower conference, 332 -334, Italy.
[18] P P Yeshajaha, M Cliftone. Food analysis theory and practice. **1994**, Chapter 37 (lipid), P. 678 – 689.
[19] A Zargari. Medicinal plants. 2nd ed. Tehran university press, **1962**.
[20] B Suryanarayana – Reddy, DK Thirumalachar. *Current Research*, Bangalore **1976**, 5 (11), 185 – 186.
[21] BagH eri, B Andalibi, Mr azimi Moghad'dam, E Zangani, S Jamshid. *Annals of Biological Research*, **2012**, 3 (3): 1202-1209.