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The effect of drought stress on agronomic traits of safflower (*Carthamus tinctorius* L.) cultivars

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Abstract

The aim of this study was to determine the influenced of draught stress on different development stages on agronomic traits of safflower (*Carthamus tinctorius L.*) under winter sowing condition in Karaj, Iran. Three known growth stages of the plant were considered and a total of 8 (including rain fed) irrigation treatments were applied. Results of this study showed that safflower is significantly affected by water shortage in the soil profile due to omitted irrigation during the sensitive vegetative stage. Highest yields were observed in the fully irrigated control. Safflower seed yield of this treatment was 4.05 ton per hectare.

Keywords: Safflower; water stress; grain yield; oil yield

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Introduction

Safflower is one of the oldest crops, but generally it has been grown on small plots for the grower's personal use (Gyulai, 1996). Drought, one of the expected results of the climate change in the region, necessitates a much more effective water use in irrigated areas. One way of increasing the water use efficiently is the practice of deficit irrigation. Due to rapid population growth, increasing food requirement and limited water resources in Iran, deficit irrigation is inevitable. Safflower, which is subsidized by the government in order to gap the cooking oil shortages both in the region and in Iran, has been increasingly used in crop rotation in the Karaj region. Therefore, knowledge on the irrigation schedule and water use efficiency of safflower under deficit irrigation condition becomes more important. This is because all field crops respond differently in different phenological stages to changing water status of the soil under deficit irrigation, which means that plants are more sensitive to water deficit at some stages than at other stages. For example, these sensitive stages are flowering and boll formation in cotton, vegetative growth in soybean, flowering and seed filling stages in wheat, vegetative and yielding stages in sunflower and sugar beet (Kirda, 2002). The purpose of the present study was to investigate the seasonal evapotranspiration, irrigation water requirement, time and number of irrigations, water use production functions and the response of safflower yield to water deficit in the soil profile during vegetative, flowering and yield formation stages, with a view to reduce irrigation with a minimum yield loss in winter sowing. Lovelli et al. (2007) showed that the harvest index in safflower did not significantly change in 5 irrigation regimes with a restoration of 100, 75, 50, 25 and 0% of the maximum crop evapotrans piration, but seed yield declined sharply when drought was severe (Lovelli et al., 2007). Yau, (2006) indicated that late sowing of spring safflower in a semiarid and high-elevation Mediterranean environment resulted in lower seed yield as later flowering does not allow an escape from the terminal drought and heat. It was reported that the seed yield of safflower decreased sharply when drought stress was severe (Lovelli et al., 2007).

Materials and Methods

Field experiment was conducted on field of the Agricultural farm of Karaj located at Karaj Region in

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Iran for the winter sowing in 2009. Daily climatic parameters were measured at a weather station located very close to the experimental sites. Cultivars of Dinger, the most popular variety in the region, were sown on September 14, 2009. Each experimental plot was designed as 2.5m wide x 6 m long (6 rows per plot) at sowing. Row spacing was 30 cm and plant spacing was 12 cm. Nitrogen and phosphorus fertilizer at 135 N (kg/ha) was applied before sowing. In the selection of irrigation treatments, three different growth stages of safflower, vegetative (V, heading stage), flowering (F, approximately 50% level) and yield formation (Y, grain filling) were considered. The treatments were as follows: non-irrigation (rain-fed), one irrigation at vegetative stage (V), one irrigation at flowering stage (F), one irrigation at yield formation stage (Y), two irrigations at vegetative and flowering (VF), two irrigations at vegetative and yield formation (VY), two irrigations at flowering and yield formation (FY), and three irrigations at vegetative, flowering and yield formation (VFY). VFY treatment was the control. Field trials were laid out in a randomized complete block design, with three replications. All experimental treatments were irrigated at the same time as the VFY treatment, watered at each growth period. All the experimental treatments were harvested at the same time as the VFY treatment, on June 28, 2010. The grains of approximately 0.25 kg per plot were oven-dried to constant weight at 65°C and reweighed to determine the moisture content. The seed yields were adjusted to a standard grain water content of 12% total seed yield and 1000 seed-weight were measured. Plant growth components of safflower were measured at the harvest time. Data were subjected to variance and regression analyses. Duncan multiple range tests was used to compare treatment means.

Results and Discussion

The grain yield, 1000-seedwight and oil yield values of each treatment and their Duncan groupings are given in Table (1). Data obtained from the study showed that seed yield was significantly ($P<0.01$) affected by soil water deficits. On the other hand, yields of experimental treatments were dependent on precipitation and its distribution during the growing period. The highest yield was obtained from VFY treatment as 4756 (kg/ha). It was followed by VF with 4125 (kg/ha) seed yield. V treatment (irrigation at vegetative period) was the highest yield among single irrigation treatments and had a yield loss of (3854 Kg/ha) compared to VFY. The lowest seed yield was obtained from no irrigation treatment. Safflower yield data in different areas under rain-fed and irrigated conditions are also available. For instance, seed yields from 1.0 to 3.3 t/ha were obtained in Sacramento Valley of California, USA (Cavero et al., 1999), in the Ariana of Tunisia (Hamrouni et al., 2001), in the Pampas region of Argentina (Quiroga et al., 2001), in the Potenza of Italy (Lovelli et al., 2007), in the Orissa of India (Kar et al., 2007). The yield obtained in the present study is higher than the above presented values. Applied irrigation treatment is one of the most important reasons for this. The highest average thousand-seed weight was recorded in the fully irrigated control (VFY). All V treatments, i.e. the treatments in which one irrigation was made at the vegetative stage, had higher thousand seed weight than others. This was followed by treatments with F (irrigation at flowering stage) and F (irrigation at yield formation stage). The lowest values for this variable were obtained from non-irrigated (rain-fed) treatment. Irrigation water amounts applied to the treatments and seasonal water consumption values of the treatments are presented in Table 2. Total irrigation water applied to irrigation treatments was strongly affected by the amount and distribution of precipitation during the trial season. Evidence for this is the differences in amounts of irrigation water applied in single irrigation treatments. Treatments with the highest amount of applied irrigation water are yield formation (Y) and flowering (F) stages. The lowest amount of irrigation water was applied in vegetative stage when the effect of winter precipitation still continues and the soil moisture is partly enough. Seasonal plant water consumption was calculated for each treatment using soil water content, irrigation water applied and precipitation. Seasonal plant water use increases with the increasing amount of irrigation water. The lowest plant water consumption was realized in non-irrigated treatment as 182 mm, followed one irrigation treatments of V, F and Y. The highest water consumption was at VFY treatment as 364 mm. The highest monthly ET values of treatments were in different months: it was in May for the V treatment, in June for the rain-fed, F, FY, VF, and VFY treatments, and in July for the Y and VY treatments. The highest monthly water consumption was in VFY treatment in June as 122 mm. Water consumption values recorded in the present study is in accordance with the ones reported by Lovelli et al. (2007) and Kar et al. (2007). Results from different climate and soil conditions, different sowing periods and cultivars showed that safflower has a seasonal water consumption of 200–1000 mm (Doorenbos and Kassam, 1979).

Conclusions

According to the results obtained, three irrigation treatments resulted in the highest seed yield as expected. This treatment almost doubled the safflower seed yields compared to non-irrigated treatment. However, yields from all of the two-irrigation treatments were not different from three irrigation treatments and some of them (VF) had yield losses of as low as 8%. If the irrigation period is selected carefully, e.g., in vegetative period, even one time irrigation can provide about 72% of the yield achieved by three irrigations.

Table 1: The effect of irrigation treatments on seed and oil yield of safflower

Treatments	Seed yield ($kg.ha^{-1}$)	1000- seed weight ($gr.1000^{-1}$)	Oil content of seed (%)	Oil yield ($kg.ha^{-1}$)
VFY	4756 a	51a	30.3ab	1624a
VF	4125ab	52ab	32.5ab	1531a
VY	4012ab	53ab	34.0a	1451a
FY	3645abc	50ab	31.5b	1223ab
V	3854bc	52ab	32.3ab	1185abc
F	3054cd	49b	32.7ab	1050bc
Y	2920cd	49b	32.3ab	978bc
C.V.(%)	6.8	3.5	4.4	15.3

NS, non-significant; ** means with the same letter within a column are not significantly different at $p < 0.01$ level based on Duncan's multiple range test.

Table 2: The effect of irrigation treatments on water quantities, irrigation water saved and evapotraspiration of safflower (mm)

Experimental treatments	Total amount	Irrigation water	Evapotras-piration	Number of
VFY	183	-	364	3
VF	111	20	293	2
VY	124	16	306	2
FY	131	14	313	2
V	52	36	234	1
F	59	34	241	1
Y	72	30	254	1

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