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ORIGINAL ARTICLE

Study of interrupting irrigation effects at different growth stages on grain and oil yields of new safflower varieties.

M. Sharrifmoghaddasi and A.H. Omidi

Islamic Azad University/ Saveh Branch Iran and Seed and Plant Improvement Institute (SPII)

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ABSTRACT

Interrupting irrigation effects at different growth stages on grain and oil yiels of safflower varieties were evaluated at Research Farm of Islamic Azad University Saveh Branch Iran in2008-2010. Varieties in 4 levels including: Goldasht, Padideh, Sina and K.W.2 and interrupting irrigation in 3 levels including: S1 (flowering), S2 (seed developing) and S3 (control), were arranged in a factorial form in a RCBD with four replications. The results of combined analysis demonstrated that interrupting irrigation significantly affected of the number of days to maturity, seed and oil yields, number of seed per head, number of branches at 1% probability level. The highest grain and oil yields belonged to Padideh cultivar (2300, 667 Kg/ha)in non-stress conditions, that showed no difference with S2(seed developing) with 2298 and 643g/ha respectively. The highest damage on grain yield caused by S1(flowering stress), It means flowering is an important stages in safflower growth period, while the lowest damage observed at S2(seed developing) and S3(control) , it was concluded that the results of S2 stage could be used for the safflower cultivars. The highest rate of total dry matter (TDM) observed at S3(control) level and padideh cultivar in the flowering time.As a recommendation the safflower farmers can ruptured irrigation in safflower seed developing stage without much seed yield decreasing.

Key words: Safflower,drought stress,

Introduction

Safflower has been grown for centuries from China to the Mediterranean region and all along the Nile valley up to Ethiopia. Presently it is grown commercially in India, the U.S., Mexico, Ethiopia, Kazakhstan, Australia, Argentina, Uzbekistan, China, and the Russian Federation. Pakistan, Spain, Turkey, Canada, Iran.

Safflower as a native crop of Iran with high tolerance to drought stress and good oil quality has an important role in expansion of cultivation area.

Commercial production of safflower in the Iran was started in the 2000s, and the area rapidly increased to 10000ha mainly in the province of Isfahan[10].

Iran is attempting to increase local production of oil crop to decrease oil importations and safflower is considered as a potential important oil crop for the country[9].

Safflower can be grown in the semi arid regions of the world for use as vegetable and industrial oils and birdfeed[14,4]. In Iran these regions mostly are cultivated by winter wheat that is why it is very important agronomic benefit to the cropping system and also improves the farmers' economic position. Continuous wheat cultivation is not recommended, and also no suitable rotation has restricted the wheat production[10].

Safflower has deep roots that can tap stored subsoil moisture[12,1,13]. Therefore; yield depends

Corresponding Author
M. Sharrifmoghaddasi, Islamic Azad University/ Saveh Branch Iran and Seed and Plant Improvement Institute (SPII)
E-mail: memo1340@yahoo.com

on accessing deep soil moisture in addition to growing-season rains. Also, safflower is a long season crop, so it can use late-season rainfall. These qualities, rather than true drought tolerance, allow it to produce well in dry areas, and to endure periods of drought.

As long as the soil is moist to a depth of 60 to 75cm (24 to 30 inches) at seeding time, a reasonable safflower crop can be expected.Safflower needs more moisture to germinate than cereals, and seed must be placed in, not just on, the moist layer of soil[7].

The effects of water stress on safflower yield has an important goal in research activities in Iran. Jones and. Mundel, [7] found that irrigation of safflower fields before planting time produced higher seed yield.

Hashemi Dezfuli[3] indicated that water stress caused plant height and number of heads decreasing in safflower.

The amount of water available the crop is an important key in seed yield and yield component in safflower. The best irrigation regimes must be determined precisely in

Local conditions[11]. Marita and Muldoon[5] reported that water stress in flowering time is the sensitive stage in safflower. The highest yield damage observed in this condition.

Seed oil concentration is poorly affected by drought stress and was shown to highly depend on the genotype[2].

Omidi[10] in study of drought stress effects at different growth stages of new safflower varieties reported that the highest damage on seed yield caused by blooming and flowering stress. The lowest damage was observed in seed developing.it was concluded therefore that this growth stage could be suitable for irrigation interrupting in safflower cultivars.

Thus this study was planned to evaluation of interrupting irrigation effects at different growth stages of new safflower varieties.

Materials and Methods

In order to study of interrupting irrigation effects at different growth stages on grain of safflower, an experiment was carried out over a two –year period(2008-2010) in Saveh university at50°,20"and 35°,16" with an altitude of 1030 m above sea level. Based on meteorological statistics, the annual rainfall is 250-300 mm, mean annual air temperature are +35c °,maximum and minimum absolute annual temperature are +44 c ° and -11 c ° respectively. The table 1 shows to the soil farm trial characters. (Table1).

Varieties in 4 levels including: Goldasht, Padideh, Sina and K.W.2 and interrupting irrigation in 3 levels including: S1 (flowering), S2 (seed developing) and S3 (control), were arranged in a factorial form in a RCBD with four replications. Each plot was composed of four lines of 6m long. After emergence, manual thinning was used to obtain normal density. For the experiment, 70kg/ha of P_2O_5 as ammonium phosphate and 25kg/ha of nitrogen as urea were supplied prior to sowing and 30kg/ha of nitrogen as urea at the start of stem elongation. Weeds were controlled by manual weeding before stem elongation. The four tested cultivars selected from the native genotypes.

Irrigation as control was applied in seven times, at emergence, stem elongation, bud formation, beginning of flowering, 50% of flowering, end of flowering and seed filling components and other agronomic traits were recorded on 10 plants randomly selected from the two middle rows. Agronomical measurements included days to bud formation, days to flowering, days to maturity, plant height (from ground level to the tip of main stem at maturity time, in cm), number of head and seeds number per head. Total biomass and thousand seed weight were determined of oven-dried samples at 80°99 C for 48 h. Seed weight per capita was calculated as the product of seeds number per head by 100 seed weight. Seeds were analyzed for the determination of oil content (in per cent), determined by Nuclear Magnetic Resonance Spectroscopy.

Statistical analysis was performed using SAS version 8.0. Data on yield per plant and yield components and other agronomic traits were recorded on plants randomly selected from the two middle rows. The harvesting areas for determination of seed yield, after deletion of the plot sides, were from two middle rows. The data for each experiment were analysed by MSTATC software for comparison of the mean values by the Duncan test at the 1% level.

Results

After homogeneity test for error variances, combined analysis of variance was performed. F.test of different sources of variation revealed that the effect of stress × year × cultivar interaction were non significant for all traits. Analysis of the grain yield showed significant differences for the cultivar, stress and cultivar× stress interaction. (Table2).

Means of grain yield and yield component in different cultivar levels showed that the highest seed yield(2168 Kg/ha) achieved from padideh cultivar.

The results of cultivar× stress interaction indicated that the highest seed yield (2300 Kg/ha) was belong to Padideh cultivar in normal irrigation,that showed no difference with interrupting irrigation at seed filling stage with 2298 kg/ha.

Significant year effect was noted, for seed and oil yields,seed per head, 100.S.W and plant height. Highly significant effects of the water stress were found on grain and oil yields, the number of seed per head, plant height and secondary branches.

Table 1: Soil farm trial characters at two depth

Soil depth	N%	p%	K%	PH	ECDs/cm	Soil Texture
0-30	0.67	15.1	100	7.1	3.2	CmSilty clay Loam,
30-60	0.77	13.3	88	7	1.1	Silty Loam

Table 2: Combined analysis of variance for grain yield, yield component and some agronomic traits in 4 safflower cultivars

S.O.V.	df	Seed yield	Oil yield	No of head	No of seed/head	100S.W	Days to maturity	No of secondary
Year	1	39483509**	23561837**	14.21ns	339**	11.85**	3698.3	29111**
R×Y	6	333643	42500.2	589	Nov-69	1.69	2455.3	1011
S	2	24435038	2900031.02**	192.57ns	199.8**	0.22ns	1011**	666.21**
Y×V	2	494222	450127.14**	115ns	1.2ns	0.18ns	256.6	75ns
E1	3	2316999	531702.25**	999**	180/36**	1.36**	995.3**	925.7**
Cultivar	3	465587	11746ns	20ns	1.2ns	.0.04ns	225.6	44.11ns
S×Y	6	5632706.144**	50559.33ns	809**	108.41**	0.03	177..33	22.99ns
V×S	6	22003.759ns	21650.13ns	216ns	9.33ns	0.01ns	201.3ns	12.2ns
V×S×Y	66	447055.702	13112/55	116	21/34	0.9	196.3	167.3

** Significant at the 1% probability level
ns=Non significant

Different drought stress levels also significantly affected days to maturity. Interactions between stress × cultivar were not significant, for oil yield,100.s.w.days to maturity, plant height and secondary branches. The highest number of head per plant was related to Padideh cultivar. There was no significant difference in stress levels, while Stress ×cultivar was significant for the trait. The highest head per plant (19) was belong to V1S1(padideh cultivar in normal condition),as usually there is a significant correlation between seed yield and the number of head per plant.

In other hand existence of high heads demonstrated that there is a relation between the number of secondary branches in plant and number of head,that is why the highest secondary branches(13) was produced by Padideh cultivar.(Table3 and 4)

Discussion

Grain and oil yields were significantly higher under normal irrigation (S3) than under different interrupting irrigation, and decreased as drought stress was applied early in the growth cycle.No significant differences were observed for the traits when interrupting irrigation was applied at seed filling stage. Number of head per plant was less affected than other traits by water stress. Grain and oil yields were reduced 75% and 73%, respectively. The number of branches per plant also decreased (72%)as the drought stress occurred early in the growth cycle.

The number of head was not significantly affected by drought stress

Seed and oil yield were significantly higher in the cultivar Padideh, compared to the other three cultivars. Padideh had higher head per plant,oil yield and seed per heads than other cultivars,

All cultivars were strongly affected by interruption of irrigation at flowering time for seed and oil yields but most traits such as number of head per plant,,100.S.W and seed per head were less susceptible to water Stress.).

The results indicated that the highest rate of total dry matter (TDM) observed at S3(control) level and padideh cultivar in the flowering time.

Total dry matter increase continuously until 240 days after planting (flowering time) and then a decrease rate was observed. The amount of total dry matter was low in S1 (interrupting irrigation at flowering stage) and S2(interrupting irrigation seed filling stage) Stages was lower than check treatment.It may be related to reduction of LAI and NAR, as water stress caused decrease causes more leaves shattering and more observed sun light by left leaves specially, in flowering time. (Figure 1)

No difference was observed for rate of total dry matter (TDM) in cultivars until 240 days after planting time although padideh cultivar showed more TDM after this stage. (Figure 2)

Table 3: Means of grain yield, yield component in safflower varieties and drought stress levels

Treatment	Grain yield	Oil Yield	100.S.W	No/ head	No/ seed/head	Days to maturity	No/ branches
Cultivars							
V1	1595 b	376.6c	31.7a	12. b	38a	295a	10a
V2	2168a	621a	31.88a	17a	36a	299a	11.3a
V3	1753b	509a	32.1a	13b	36a	298a	9.9a
V4	1660b	466a	32a	13b	31b	300a	11a
Stress							
S1	1499b	409b	30.4a	13.3a	34.7b	294b	9.1b

S2	1882a	509a	28.44b	13.4a	33.5b	295b	8.9b
S3	2000a	561a	34.22a	13.6a	38.5a	304a	12.5a

Means with same letters in each column are not significantly different at 1% of probability level.
V1=Goldasht, V2= Padideh, V3=Sina, V4=K.W.2
S1= Interrupting irrigation at flowering stage, S2= Interrupting irrigation seed filling stage,
S3= Normal irrigation

Table 4: Means of V×G of grain yield, yield component in 4safflower varieties

Treatment	Grain yield	Oil Yield	100.S.W	No/ head	No/ seed/head	Days to maturity	No/ branches
Cultivar× Stress							
V1S1	1100c	264c	35a	9b	38a	294b	9b
V1S2	1780b	409b	37a	13b	35a	297a	8b
V1S3	1905b	457b	37a	15a	41a	294b	10ab
V2S1	1907b	553a	31b	15a	37a	295a	9b
V2S2	2298a	643a	32b	17a	32a	295a	9b
V2S3	2300a	667a	33ab	19a	39a	308a	13a
V3S1	1500c	420b	29b	12b	35a	293b	8b
V3S2	1760b	528ab	27b	13b	35a	294b	8b
V3S3	2000ab	580a	28b	14ab	38a	307a	10ab
V4S1	1490c	402b	30b	13b	29b	295a	11a
V4S2	1690bc	456b	32b	13b	32a	297a	10ab
V4S3	1800b	540a	33b	14ab	36a	310a	12a

Means with same letters in each column are not significantly different at 1%. probability level.

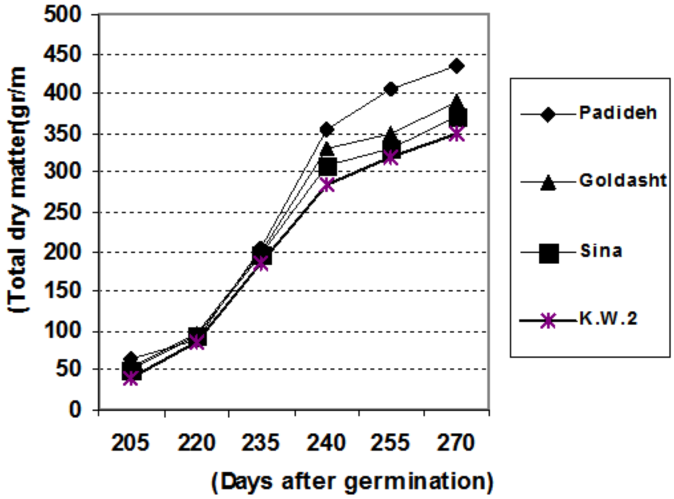

Fig. 1: Today dry matter in cultivars.

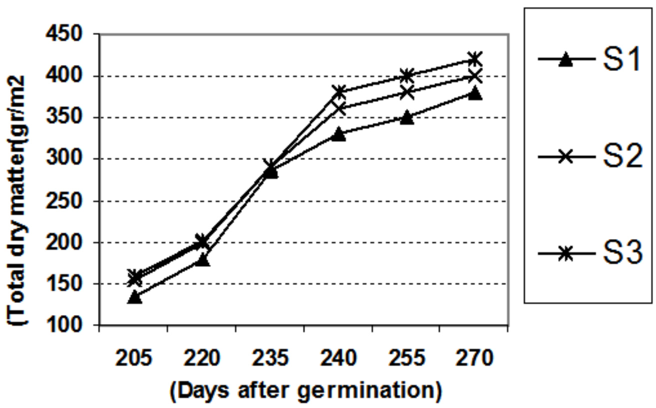

Fig. 2: Today dry matter in stress levels.

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