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Original article

Investigarion of delayed planting and cutting off irrigation effects on biochemical traits, relative water content and yield of two safflower (*Carthamus tinctorius*) cultivars

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Extended abstract

Introduction

Water stress is a non-living stress that causes different biochemical and physiological reactions in the plant but the amount of damage caused by stress depends on the severity, time and duration of stress. Introducing the best planting date in combination with suitable irrigation regime is one of the effective strategies in stress management. Among the oilseeds that are compatible with the conditions of the country, safflower is known as a water-resistant plant due to its long roots, with high absorption capacity from deeper parts of the soil. Also, since planting time controls the phenological stages of the plant and the whole production, therefore, choosing the appropriate planting date and exposure to water stress is one of the most important determinants of crop production. The aim of this study was to investigate the effect of delayed planting date and irrigation regime on biochemical traits, relative water content, biomass yield and safflower seed yield.

Materials and Methods

In order to study delayed planting date and irrigation regime on biochemical traits, relative water content and seed yield of safflower, a field experiment was conducted as split factorial in a completely randomized block design with three replicates, during 2018-2019 growing season at research station of College of Agriculture and Natural Resources of Darab, Shiraz University. Experimental factors included irrigation regime as main factor at three levels of normal irrigation, cutting irrigation at flowering stage and cutting irrigation at seed filling stage, and sub-factors including three planting dates (6 December, 26 December and 15 January) and two safflower cultivars (Goldasht and local Isfahan). In this study, chlorophyll a content, chlorophyll b content, carotenoid content, catalase and peroxidase activity, relative water content, canopy temperature, biomass yield and grain yield of safflower cultivars were calculated. Finally, analysis of variance (ANOVA) was performed using SAS v. 9.4 and the means compared by LSD test at 1% probability level.

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Results

Overall, the results showed that the measured traits were significantly affected by irrigation regime, planting date and cultivar. Cutting off irrigation at flowering reduced chlorophyll a and b content, relative water content and grain yield of safflower cultivars by 25, 15.38, 16.36 and 33.74%, respectively, while carotenoid, catalase enzyme content, peroxidase and canopy temperature were increased by 14.70, 22, 29.31 and 21.75, respectively. Also, delayed third planting date (15 January) decreased chlorophyll a and b content, catalase activity, peroxidase activity, biomass yield and grain yield while carotenoid content, relative water content and canopy temperature increased .

Conclusion

The highest yield was obtained in Isfahan local cultivar at the second planting date (26 December) in normal irrigation treatment which had no significant difference with cutting off irrigation at seed filling on the first sowing date (6 December) in Isfahan and Goldasht local cultivars. Water stress at flowering and grain filling stages decreased the grain yield by 52.32% and 34.54%, respectively. Under cutting off irrigation at grain filling stage, the plant has been able to compensate yield loss more than flowering stage by performing biochemical and enzymatic activities at the time of stress occurrence. Also, as the second planting date (26 December) increased chlorophyll a, b, carotenoid content, relative water content and canopy temperature and subsequently more yield was observed than the other two planting dates, so choosing the optimal planting date (26 December) and early mature Goldasht cultivar can play an important role in improving yield of safflower under late-season water stress conditions in Sothern Iran.

***Keywords*:** Peroxidase, Goldasht cultivar, Photosynthetic pigments, Catalase, Cutting off irrigation.

Table1. Physical and chemical properties of soil in experimental site

Soil depth	Sand	Clay	Silt	O.C	BS	EC	(pH)
cm	----------%----------					$dS.m^{-1}$	
0-15	38.12	17.18	44	0.977	8.88	1.092	7.42
15-30	38.16	17.26	44	0.970	8.93	1.090	7.54
Soil depth	**N**	**P**	**K**	**Fe**	**Cu**	**Zn**	**Mn**
cm	%	----------$mg\ kg^{-1}$----------					
0-15	0.084	54	320	5.104	1.61	0.564	14.8
15-30	0.084	58	300	7.30	1.63	0.540	14.8

Table 2. Analysis of variance (Mean Square) of measured traits of two safflower cultivars under irrigation regime and planting date

S.O.V	df	Chlorophyll a content	Chlorophyll b content	Carotenoid content	Catalase	Peroxidase
Replication (R)	2	0.00116**	0.00101**	0.0001185^{ns}	0.13573**	0.21249**
Irrigation regime (I)	2	0.09122**	0.00197**	0.0108018**	0.95967**	2.14792**
Main Plot Error	4	0.0000490	0.0000435	0.00065463	0.011412	0.031451
Planting date (D)	2	0.00536**	0.00086**	0.0017851*	1.21467**	0.52516**
Cultivar (C)	1	0.00006^{ns}	0.00036^{ns}	0.0146685**	0.16006**	0.27164**
I × D	4	0.01604**	0.00155**	0.0041879**	1.09795**	0.26176**
I × C	2	0.00215**	0.00094**	0.0023574**	0.04377**	0.04016^{ns}
D × C	2	0.00135**	0.00131**	0.0063629**	0.35475**	0.17520**
I × D × C	4	0.01281**	0.00079**	0.0044768**	0.23794**	0.10404**
R × (DC)	10	0.00068**	0.00015**	0.0000023^{ns}	0.00007^{ns}	0.00024^{ns}
Subplot Error	20	0.0000375	0.00003615	0.000425	0.00734	0.018006
CV (%)		*1.87*	*5.17*	*6.46*	*5.08*	*6.70*

Table 2. Continued

S.O.V	df	Relative water content	Canopy temperature	Biological yield	Grain yield
Replication (R)	2	0.5980^{ns}	15.0046**	47496.30^{ns}	3272.222^{ns}
Irrigation regime (I)	2	339.0853**	460.004**	3105162.9*	1382616**
Main Plot Error	4	0.83147	3.5879	1045118.5	847.222
Planting date (D)	2	2.8596^{ns}	36.2407*	3347449**	146405.5**
Cultivar (C)	1	141.555**	6.000*	1363266^{ns}	378340.7**
I × D	4	6.0207*	16.0324**	2634285.1*	120605.5**
I × C	2	0.88372^{ns}	3.7916^{ns}	12346200**	68457.4**
D × C	2	25.6368**	19.0555**	1150866.6^{ns}	120535.1**
I × D × C	4	4.3926*	8.7638**	5007433**	98551.8**
R × (DC)	10	17.439**	0.5697^{ns}	115471^{ns}	8356.03**
Subplot Error	20	0.76452	1.3819	736518.7	625.18
CV (%)		1.93	3.01	8.14	8.27

ns, * and ** are non-significant and significant at 5% and 1% probability levels

Table3. Mean comparison of plant traits in two safflower cultivars under irrigation regime conditions and planting date

Irrigation regime	Planting date	Cultivars	Chlorophll a content	Chlorophll b content	Carotenoid content
			----------mg. g^{-1}Fw----------		
Normal irrigation	(6 Dec)	Goldasht	0.63^{a}	0.15^{a}	0.33^{abc}
		Local Isfahan	0.57^{c}	0.10^{ghi}	0.20^{g}
	(26 Dec)	Goldasht	0.49^{f}	0.11^{efg}	0.32^{bcd}
		Local Isfahan	0.56^{c}	0.13^{cd}	0.34^{abc}
	(15 Jan)	Goldasht	0.53^{d}	0.13^{bc}	0.27^{ef}
		Local Isfahan	0.59^{b}	0.14^{ab}	0.31^{cde}
Cutting of irrigation at flowering	(6 Dec)	Goldasht	0.36^{j}	0.12^{def}	0.37^{a}
		Local Isfahan	0.38^{i}	0.12^{de}	0.37^{a}
	(26 Dec)	Goldasht	0.53^{d}	0.11^{fgh}	0.33^{abc}
		Local Isfahan	0.41^{h}	0.11^{ef}	0.33^{abc}
	(15 Jan)	Goldasht	0.40^{h}	0.08^{j}	0.35^{abc}
		Local Isfahan	0.44^{g}	0.11^{efg}	0.31^{cde}
Cutting of irrigation at seed filling	(6 Dec)	Goldasht	0.56^{c}	0.11^{fgh}	0.34^{abc}
		Local Isfahan	0.54^{d}	0.12^{def}	0.26^{f}
	(26 Dec)	Goldasht	0.51^{e}	0.12^{def}	0.34^{abc}
		Local Isfahan	0.59^{b}	0.15^{a}	0.32^{bcd}
	(15 Jan)	Goldasht	0.50^{ef}	0.09^{ij}	0.36^{ab}
		Local Isfahan	0.43^{g}	0.10^{hi}	0.28^{def}
LSD			*0.01167*	*0.01111*	*0.04130*

Table 3. Continued

Irrigation regime	Planting date	Cultivars	Catalase	Peroxidase	Biological yield	Seed yield
			$U.min^{-1}.g^{-1}.Fw$		----------kg. ha^{-1}----------	
Normal irrigation	(6 Dec)	Goldasht	1.44^{hi}	1.93^{d}	8766.6^{d-h}	1350^{e}
		Local Isfahan	1.80^{g}	1.54^{ghi}	12566.6^{a}	1390^{e}
	(26 Dec)	Goldasht	1.20^{jk}	1.59^{f-i}	9700^{bcd}	1390^{e}
		Local Isfahan	1.09^{k}	1.35^{i}	10300^{bcd}	1650^{a}
	(15 Jan)	Goldasht	1.84^{fg}	1.65^{e-h}	7653.3^{ghi}	1370^{e}
		Local Isfahan	1.99^{def}	1.78^{d-g}	7700^{f-i}	940^{g}
Cutting of irrigation at flowering	(6 Dec)	Goldasht	2.17^{bc}	2.69^{a}	11333^{ab}	933.33^{g}
		Local Isfahan	2.83^{a}	2.34^{b}	9000^{d-g}	820^{h}
	(26 Dec)	Goldasht	2.24^{b}	2.29^{bc}	9486^{cde}	1070^{f}
		Local Isfahan	1.90^{efg}	2.70^{a}	8866^{d-g}	786.66^{h}
	(15 Jan)	Goldasht	1.59^{h}	2.03^{cd}	6153.3^{i}	930^{g}
		Local Isfahan	1.27^{ij}	1.85^{def}	7133.3^{hi}	820^{h}
Cutting of irrigation at seed filling	(6 Dec)	Goldasht	1.88^{efg}	2.23^{bc}	10900^{abc}	1580^{bc}
		Local Isfahan	2.10^{bcd}	1.93^{d}	9566.6^{cde}	1610^{ab}
	(26 Dec)	Goldasht	1.43^{hi}	1.91^{de}	10300^{bcd}	1500^{d}
		Local Isfahan	2.02^{cde}	1.88^{de}	7633.3^{ghi}	1080^{f}
	(15 Jan)	Goldasht	1.40^{i}	1.81^{d-g}	9333.3^{c-f}	1540^{cd}
		Local Isfahan	1.17^{jk}	1.49^{hi}	8000^{e-h}	1060^{f}
LSD			*0.1723*	*0.2797*	*1679*	*48.76*

Means with similar letters based on LSD test showed no significant difference at 5% probability level.

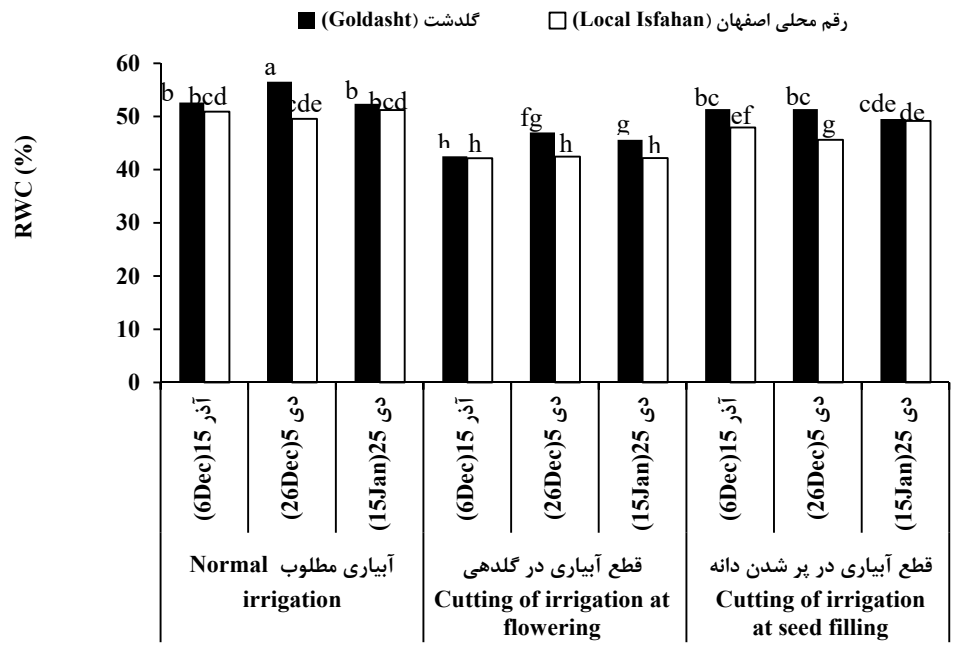

Fig. 1. Interaction effect of irrigation regime, planting date and cultivar on safflower Leaf relative water content (RWC). (Means with similar letters are not significantly different based on LSD test at 1% probability levels).

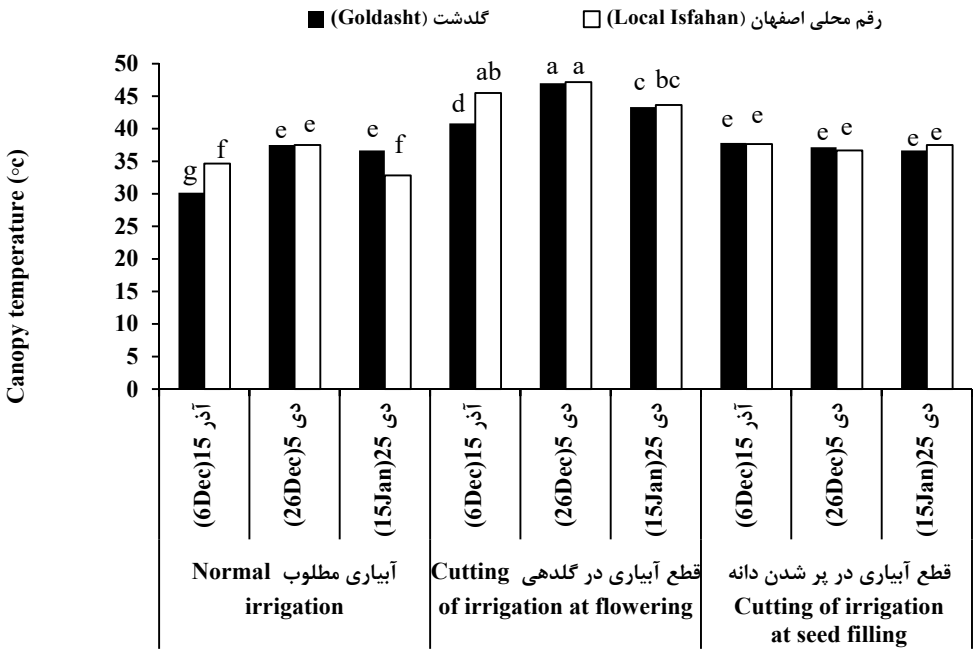

Fig. 2. Interaction effect of irrigation regime, planting date and cultivar on canopy temperature of safflower. (Means with similar letters are not significantly different based on LSD test at 1% probability levels).