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Original article

Evaluation of drought tolerance indices on unsaturated fatty acids and some physiological traits of four safflower (*Carthamus tinctorius* L.) cultivars in Jiroft

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Extended abstract

Introduction

Safflower (*Carthamus tintorius* L.) belongs to Compositae or Asteracea family. Safflower is a branching, thistle-like herbaceous annual. In semi-arid regions safflower is widely used for oil, natural color, biodiesel fuel and rottion (Nogales-Delgado et al., 2019). Safflower seed oil contains high amounts of saturated (palmitic and stearic) and unsaturated (oleic, linoleic, and linolenic) fatty acids that may be affected by abiotic drought stresses (García-Moreno et al., 2014). Water is one of the limiting factors affecting the physiological and biochemical processes of plants (Stránský et al., 2005). The severity and timing of drought stress affect seed and oil yield (Lovelli et al., 2007). One of the important issues in evaluating cultivars and genotypes for drought tolerance is quantitative measurement of drought tolerance indices. This study was carried out to determine the best drought tolerant cultivars of safflower with drought tolerance indices in Jiroft region.

Materials and Methods

A field experiment was conducted at the experiment station of Faculty of Agriculture, University of Jiroft at 2018-2019 growing season. A split plot with randomized complete block design with four replications was used. Main plots were two levels of irrigation regimes (irrigation after 80 mm cumulative evaporation from evaporation pan class A and no irrigation from flowering to maturity stage) and sub-plots included safflower cultivars including Sina, Padideh, Zarghan and Zhila. Irrigation was conducted as drip system. The first irrigation was done after sowing seeds. In order to dorought stress, plants were not irrigation at 50% flowering stage to the physiological maturity stage. Chlorophyll a, b (Arnon, 1967) and carotenoids (Lichtenthaler, 1987) were used. Fatty acids were measured by the method (Primomo et al., 2002). Analysis of variance was done by SAS vs 9.4 software.Comparison of mean treatments under stress and non-stress conditions with t-test and comparison mean cultivars based on LSD test were calculated at 5% level ($p < 0.05$.). Response to stress was evaluated in both stress and non-stress conditions using quantitative stress tolerance indices.

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Results

Drought stress significantly reduced the traits studied in this study. The results showed that drought stress significantly reduced 1000-seed weight, seed yield, oil percentage and leaf chlorophyll content but leaf carotenoid content was not significant. Chlorophyll content was less than full irrigation and Zarghan had the highest chlorophyll content and Zhila had the lowest chlorophyll content. In safflower, drought stress decreased the amount of unsaturated fatty acid and the ratio of linolenic and linoleic acids (Hamrouni et al., 2001) and chlorophyll a, b and carotenoids contents (Chavoushi et al., 2020). Seed yield decreased by 20% in irrigation treatments during flowering to maturity. Zarghan cultivar had the highest seed yield (2473 kg ha-1) and highest oil content in complete irrigation, respectively. Zarghan cultivar (47.3% oil) and highest oil stability (30%) had the highest seed yield, respectively. Zarghan cultivar had the highest oleic acid (23.4%) and linoleic acid (76.3%) among cultivars. In the study of the effect of different irrigation regimes on grain yield and oil quality, seed yield of plants under complete irrigation was 28% higher than that of plants grown in limited irrigation (Pasandi et al., 2018). The results of this study were similar to and Smith, 2005.

STI index was highest in Zaraghan and Phenida cultivars and lowest in Sina and Jila cultivars. Average productivity index (GMP) is more than unit indicating relative tolerance to stress. Phenid and Zarqan cultivars had high yield in both stress and non-stress conditions. Therefore, Zarghan, Sina, Padideh and Zhila had the lowest Relative Yield Index (RDY) and Yield Yield (YSI), respectively.

Conclusion

In general, the results of this study showed that Zarghan cultivar had the highest oleic acid (23.4%) and linoleic acid (76.3%) among cultivars. Based on drought tolerance indices, Zarghan and Padideh Cultivars had the highest indices of GMP, STI, MP, HM, and these indices were the same for determination of desirable cultivars. This study shows Sina cultivar was identified in low yield and stress sensitive conditions and Zarghan cultivar can be a promising crop for irrigated and Padideh is desirable non-irrigated areas under water stress conditions.

***Keywords*:** Carotenoid, Linoleic acid, Oil percent, Oil stability, Oleic acid, Seed Yield

Table 1. Soil physicochemical properties at the experimental location

Soil texture	Potassium	Phosphorous	Organic matter	Nitrogen	Ec	pH
	----------ppm----------		----------%----------		dS/m	
Loamy silt	209	8	0.4	0.083	1.63	8.3

Table 2. Variance analysis of measured traits in four cultivars csafflower

source of variation	Chl a	Chl b	T. Chl	CRTD×10^{-5}	Oil.p
Block	0.006^{ns}	0.003^{ns}	0.001^{ns}	4.6^{ns}	30.5*
Irrigiation (I)	1.04***	0.063***	1.61***	17.6^{ns}	1443**
Block*Irrigiation	0.016	0.002	0.015	2.06	36.5
Cultivar (C)	0.241*	0.025***	0.403*	61***	94.9**
I × C	0.136*	0.003*	0.14*	0.645^{ns}	23.6*
Block × C	0.019^{ns}		0.021	8.248*	5.07
Error b	0.028	0.001	-	1.706	-
C.V (%)	*15.98*	*8.37*	*12.93*	*1.39*	*9.87*

Table 2. Continued

source of variation	lino(C18:2)	olei(C18:1)	Oil.st×10^{-5}	1000 s.w	SYH
Block	1.793^{ns}	0.994^{ns}	22^{ns}	8.65^{ns}	20549^{ns}
Irrigiation (I)	186***	187***	1730***	203*	1949325***
Block*Irrigiation	14.7	0.237	45	3.88	2945
Cultivar (C)	184***	40.7***	210*	20.52^{ns}	394053***
I × C	29.4*	7.088***	290*	10.05^{ns}	56512**
Block × C	-	0.497^{ns}	-	7.018^{ns}	7563^{ns}
Error b	5.17	0.695	20	16.3	6246
C.V (%)	2.27	3.74	6.62	9.78	3.58

*, ** and *** significant at 0.05, 0.01 and 0.001 levels, respectively; ns: not significant. SY: seed yield,1000 s.w= the weight of one thousand seeds, Chl a =Chlorophyll a, Chl b =Chlorophyll b, t chl=Total chlorophyll, CRTD =carotenoid,lino=linoleic acid(C18:2),oli= oleic acid (C18:1), (C18:1)/ (C18:2)=oil stability

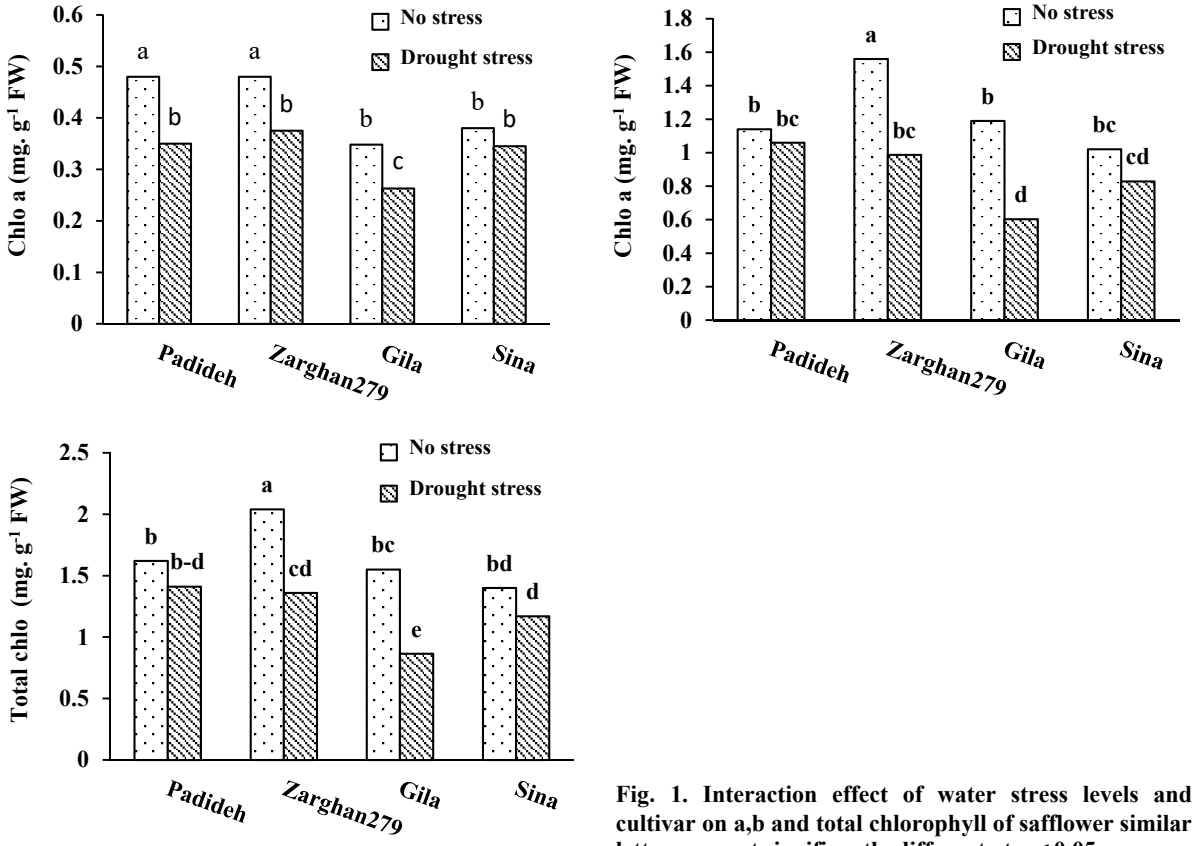
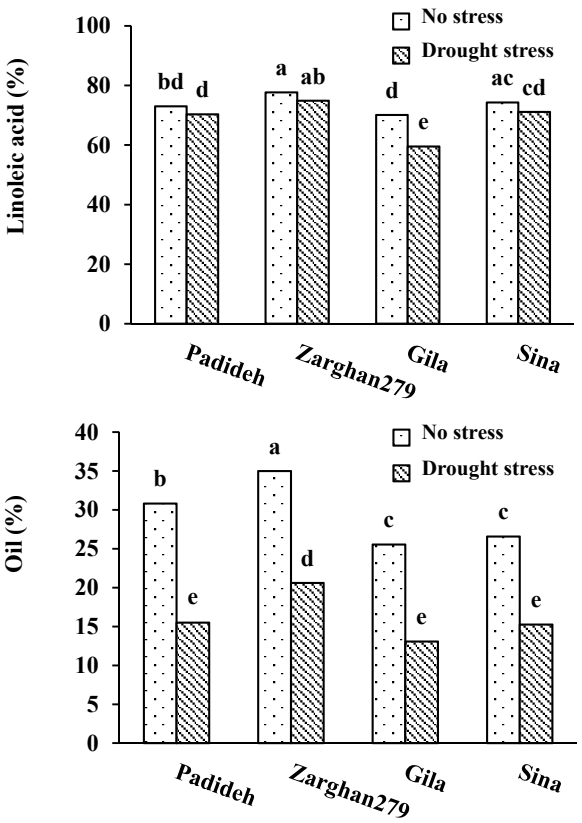


Fig. 1. Interaction effect of water stress levels and cultivar on a,b and total chlorophyll of safflower similar letters are not significantly different at p < 0.05



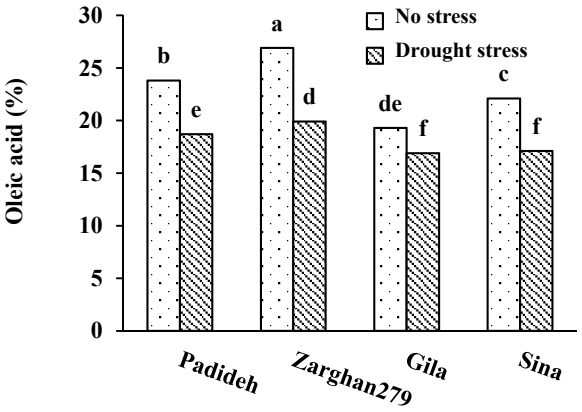


Fig. 2. Interaction effect of water stress levels and cultivar on oil percentage and Fatty Acids Content of safflower. similar letters are not significantly different at $p < 0.05$

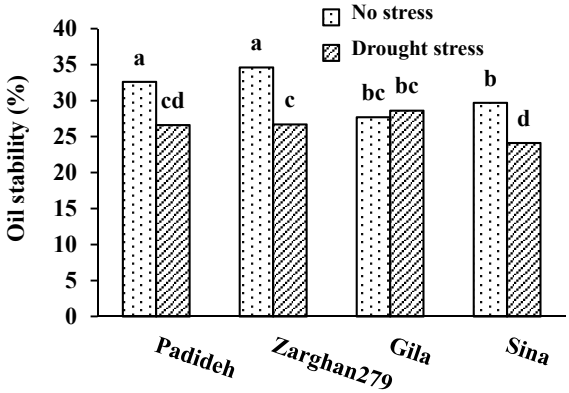


Fig. 3. Interaction of water stress levels and cultivar on oil staibility of safflower. Similar letters are not significantly different at $p < 0.05$.

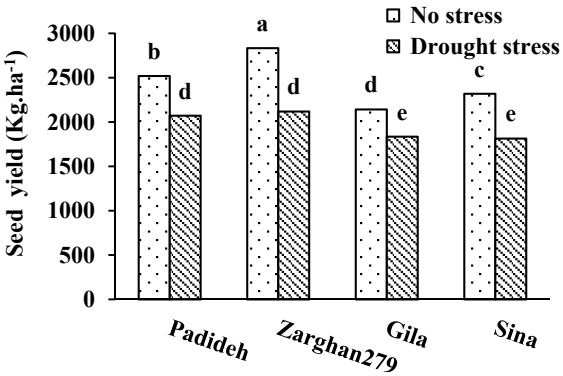


Fig. 4. Interaction of water stress levels and cultivar on seed yield of safflower. Similar letters are not significantly different at $p < 0.05$