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Original article

Effect of plant density and drought stress on important agronomic characteristics of confectionery sunflower

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Extended abstract

Introduction

In confectionary sunflower cultivation, drought stress at the stage of vegetative growth and plant density are two important variables that determine grain yield. In order to increase the 1000-seed weight and marketability of sunflower seeds, farmers usually consider plant density less than oily sunflower, and on the other hand, for more root growth and dormancy resistance due to large heads, in the vegetative growth stage of sunflower they bring drought stress to the sunflower farm. In some regions of Kermanshah province, confectionary sunflower (local cultivar Songhori) is cultivated with very low density (1-3 plants per square meter). On the other hand, farmers, based on their experiences, in the vegetative growth stage (2-6 leaves), cut off the field irrigation, and this watering interruption may take 30-45 days. The purpose of stopping irrigation in such conditions is to grow more roots and prevent lodgings of plants due to the weight of the head. In the present study, the effect of cutting irrigation at vegetative stage and plant density on yield and other agronomic characteristics of local confectionary sunflower was investigated to identify the most appropriate treatments.

Materials and Methods

The present study was conducted using split plot experiment based on randomized complete block design with three replications in the farmers' farm of Kermanshah province in 2016. Drought stress was as the main factor at three levels including severe stress, moderate stress and non-stress. The sub-factor was three levels of plant density with changes in plant space on 60 cm planting rows in the form of 20, 40 and 60 cm. Important agronomic traits including number of days to star, number of days to full flowering, stem diameter, plant height, number of leaves, leaf area, head diameter, percentage of hollow, number of seeds per head, 1000 seed weight and yield were measured according to Schneider and Miller (1981). In order to measure the grain yield of each plot, the middle row plants were harvested after removing the marginal plants (one row and one plant from the beginning and end of each plot) and the grain yield was measured after threshing. Based on the harvested area, it was converted to kilograms per hectare. In order to statistical analysis, SAS Ver 9.1 statistical software was used to analyze the variance and the means of treatments was compared by Duncan's multiple range test.

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Results and discussion

The results of variance analysis showed that drought stress significantly reduced plant height, days to maturity, seeds per head and stem diameter and increased days to flowering. Effect of Density was significant on all studied traits except plant height and number of leaves. While increasing density, stem diameter, head diameter, number and weight of seeds per head and 1000-seed weight was decreased and the hollow percentage of head, the number of days to flowering was increased. Mean comparison of data showed that grain yield under severe and non-stress condition was 2749 and 4543 kg ha^{-1}, respectively. The highest and the lowest grain yield was belonged to plant spacing of 40 cm and 20 cm with 4599 and 3538 kg ha^{-1}, respectively.

Given the water crisis in Iran, the real value of water consumption should be considered and water loss should be prevented by using different methods in crop production. According to the mean grain yield, it can be seen that the average yield of mild drought stress (two less irrigations) is slightly different from the average yield in non-stress irrigation. The two removed irrigations in the mild stress treatment coincide with the time of grain filling of crops such as wheat, barley and canola or the cultivation of some spring crops such as corn. Irrigation in these stages is important in the grain yield of these plants. So by eliminating two irrigations after the establishment of the sunflower, the saved water can be used to irrigate other crops. On the other hand, low and high density treatments both had lower grain yield than intermediate density treatment. Plant spacing of 40 cm with high 1000-seed weight had higher grain yield than plant spacing of 20 and 60 cm, so that a plant distance of 40 cm can be recommended in confectionary sunflower. It can also be recommended that, after the establishment of the sunflower plant, by eliminating two irrigations before reproductive growth, without effective reduction of grain yield, water resources can be used for other crops such as wheat, barley and canola.

***Keywords*:** Deficit irrigation, Number of plants, Sunflower, Yield

Table 1. Physical and chemical characterstics of soil at experimental site

Sampling Depth	Soil Texture	Electeric Conductivity	T.N.V.	Organic carbon	Phosphorous	Potassium
cm		dSm^{-1}	----------%	----------	----------mg kg^{-1}	----------
0-30	Silty clay	0.7	25	1.2	12.5	255

Table 2. Results of ANOVA (mean of squares) of plant density and drought stress on agronomic characteristics of confectionary sunflower

S.O.V	DF	Days to full Flowering	Days to Maturity	Hollow percentage of Head	Seed per head	Number of Lodged Plants
Replication	2	11.1^{ns}	38.5^{**}	16.2^{ns}	21928^{ns}	0.28^{ns}
Drought stress (DS)	2	112.1^{**}	63.3^{**}	1.4^{ns}	303188*	0.40^{ns}
Error a	4	6.0	0.9	4.5	26143	0.64
Plant distance (PD)	2	7.7^{*}	207.8^{**}	475.0^{**}	686207^{**}	1.32^{*}
DS×PD	4	1.3^{ns}	9.7^{**}	9.7^{ns}	42730^{ns}	0.03^{ns}
Error b		2.0	1.4	7.7	9083	0.36
CV%		*1.4*	*0.9*	*22.2*	*12.2*	*32.9*

Table 2. Continued

S.O.V	DF	Stem Diameter	Plant Height	1000 Seed Weight	Head Diameter	Grain Yield
Replication	2	3.4^{ns}	373.9^{ns}	327.2^{*}	14.4^{*}	1091477^{ns}
Drought stress (DS)	2	109.8^{**}	2288.0^{*}	32.0^{ns}	5.0^{ns}	7860371^{*}
Error a	4	5.7	306.1	40.1	1.7	563045
Plant distance (PD)	2	64.6^{**}	58.4^{ns}	2883.9^{**}	217.9^{**}	2107177^{**}
DS×PD	4	3.4^{ns}	131.1^{ns}	123.6^{ns}	3.8^{ns}	251733^{ns}
Error b		2.7	190.7	41.4	2.4	278883
CV%		*8.3*	*5.9*	*5.1*	*7.2*	*13.9*

ns, * and **: non-significant, significant at 5% and 1% levels, respectively

Table 3. Mean comparison of agronomic traits in confectionary sunflower at different level of drought stress using Duncan test at 5% probability level

Drought stress treatment	Days to full flowering	Days to maturity	Hollow percentage of head	Seed per head	Number of lodged plants	Stem diameter	Plant height	1000 Seed weight	Head diameter	Grain yield
	------- days -------		%	------- no. -------		mm	cm	g	cm	$kgha^{-1}$
Non Stress	104^{4}	130^{a}	12.3^{a}	917^{a}	4.1^{a}	22.4^{a}	246^{a}	120.6^{a}	2.1^{a}	4543^{a}
Moderate	98^{b}	128^{b}	13.0^{a}	855^{a}	3.2^{a}	21.3^{a}	232^{ab}	109.5^{ab}	21.0^{a}	4100^{a}
Severe	97^{a}	125^{c}	12.4^{a}	573^{b}	2.3^{a}	15.9^{b}	214^{b}	89.9^{b}	19.8^{a}	2749^{b}

Means that have a common letter, have not significantly different together based on Duncan test at 5%.

Table 4. Mean comparison of agronomic traits in confectionary sunflower at different level of plant space on planting rows using Duncan test at 5% probability level

Plant distance on planting rows	Days to full flowering	Days to maturity	Hollow percentage of head	Seed per head	Number of lodged plants	Stem diameter	Plant height	1000 Seed weight	Head diameter	Grain yield
	------- days -------		%	------- no. -------		mm	cm	g	cm	$kgha^{-1}$
20cm	100^{a}	123^{c}	20.8^{a}	488^{c}	4.7^{a}	17.1^{c}	233^{a}	104.6^{b}	15.2^{c}	3623^{ab}
40cm	100^{a}	128^{b}	9.9^{b}	819^{b}	2.7^{b}	20.0^{b}	228^{a}	132.5^{a}	21.8^{b}	4344^{a}
60cm	98^{b}	132^{a}	6.9^{c}	1037^{a}	2.3^{b}	22.5^{a}	231^{a}	138.0^{a}	24.8^{a}	3424^{b}

Means that have a common letter, have not significantly different together based on Duncan test at 5%.

Table 5. Mean comparison of drought stress × plant density for days to maturity of confectionary sunflower at 5% probability level

Drought Stress	Plant distance on planting rows	Days to maturity
Severe	**20cm**	136^{a}
	40cm	129^{c}
	60cm	125^{d}
Moderate	**20cm**	133^{b}
	40cm	129^{c}
	60cm	123^{c}
Non-Stress	**20cm**	127^{c}
	40cm	127^{c}
	60cm	119^{e}

Means that have a common letter, have not significantly different together based on Duncan test at 5%.