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Can methanol foliar application improve the productive performance of sunflower under water deficit stress

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Abstract

In order to investigate the effect of water deficit stress and methanol foliar application on yield and yield components of sunflower (*Helianthus annuus* L), an experiment was conducted in the split plot form based on Completely Randomized Block Design with three replications during growing seasons of 2011-2012. Treatments were water deficit stress in four levels: a_1: severe stress (25% FC irrigation), a_2: mild stress (50% FC irrigation), a_3: fair stress (75% FC irrigation) and a_4: normal irrigation (100% FC irrigation) and the foliar application of methanol in six levels [b_1:0, b_2:7, b_3:14, b_4:21, b_5:28 and b_6:35 (v/v)]. The analysis of variance showed significant effect of interaction between water deficit stress and methanol foliar application on plant height, stem and head diameter, empty and full seed number ($p<0.01$). The results showed that foliar application with 21% (v/v) methanol and normal irrigation produced 35% more plant height, 65% more head diameter. Besides, the results also proved that 14% (v/v) methanol foliar application in normal irrigation had the highest stem diameter (34 cm).furthermore, the lowest empty seed number (248) and the highest full seed number (1611) were observed for 7% (v/v) methanol and normal irrigation.

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Introduction

Water deficit is a major abiotic stress that adversely affects crop growth and yield (Jaleel et al., 2008). It decreases plant growth by affecting physiological and biochemical processes (Jaleel *et al.,* 2008; Farooq et al., 2008).The first step to achieve high yield per unit area is high production of dry matter because almost 90% of plant dry weight is resulted from CO_2 assimilation during photosynthesis. Methanol foliar application is a method which increases crop CO_2 fixation in unit area (Nadali *et al.,* 2010). Recent investigation showed that C_3 crops yield and growth increased via methanol spray and methanol may act as C source for these crops (Makhdum *et al.,* 2002). Thus, methanol spraying results in increased production and reduces plants' water requirement in warm and dry conditions (Aslani et al., 2011).The metabolism of methanol and its conversion to sugars change the osmotic potential of the leaves. It increases the turgor pressure and the pores. In fact, keeping the pores open increases assimilation and the growth rate, which leads to early maturation and decreased water requirements (Nonomura and Benson, 1992). Nadali *et al.,* (2010) stated that 21% (v/v) methanol spray poses the greatest impact on yield, and other physiological traits. Foliar applications of aqueous methanol have been reported to increase yield, accelerate maturity, and reduce drought stress (Ramirez *et al.,* 2006).

Positive effects of methanol foliar application on growth of other plant have been confirmed in previous studies. Thus, the objectives of this study were to investigate the effects of methanol foliar application and water deficit stress on some of physiological characteristics in sunflower.

Materials and methods

Field experiment

The field experiment was carried out in split plot form by Completely Randomized Block Design with three replicates at the Research Station of the Islamic Azad University, Tabriz Branch, north-western Iran, during the 2011 - 2012. The sunflower cultivar used was Recoord (a Romanian open-pollinated cultivar that is widely planted in Iran). The first factor was water deficit stress in four levels: a1: severe stress (25% FC irrigation), a2: mild stress (50% FC irrigation), a3: fair stress (75% FC irrigation) and a4: normal irrigation (100% FC irrigation). The second factor was the foliar application of methanol in six levels [b1:0, b2:7, b3:14, b4:21, b5:28 and b6:35 volumetric percentage (v/v)] that to prevent of methanol poisoning at light presence, 1 g lit-1 Glycine and 1 mg lit-1 Tetrahydrofolate (THF) were added to prepared solution (bayat et al., 2012). In all treatments, methanol spray was applied 4 times during stages of sunflower development contain: V-8 (determined by counting the number of true leaves at least 4 cm in length), R-4 (The inflorescence begins to open), R-6 (Flowering is complete and the ray flowers are wilting) and R-7 (The back of the head has started to turn a pale yellow color), (Schneiter and Miller, 1981). Flooding irrigation was conducted and all of treatments were irrigated completely prior to R-4 stage. Each plot consists of 5 rows, 60 cm row spacing and 20 cm plant interval. There were 2-5 seeds beside each other and they were thinned at three leaves stage to obtain plant density of 8 plants per m2.

Statistical analysis

In order to check the normality of data, analysis of variance, and mean comparison MSTAT-C software were used. The means of the treatments were compared using the least significant difference (LSD) test at $P< 0.05$.

Results and discussion

The analysis of variance showed significant effect of interaction between water deficit stress and methanol foliar application on plant height, stem and head diameter, empty and full seed number ($p<0.01$), (tab. 1).

Plant height

The results showed that the highest (228 cm) and the lowest (168/5 cm) plant height were for treatments (a4b4) and (a_1b_1), respectively (tab.2, fig. 1). This treatment (a_4b_4) produced 35% more plant height than 0% methanol foliar application in severe stress treatment. This study showed that levels of methanol

effected all characteristics and methanol spraying decreased the negative effects of water deficit stress. Interestingly, water deficit stress condition, plant height was reduced with increase in amount of methanol from 28- 35 [v/v].

Table 1. The analysis of variance of measured traits in experiment.

S.O.V	df	Plant height	Stem diameter	Head diameter	Empty seed number	Full seed number
Rep	2	12/76ns	3/0316ns	7/87ns	2959ns	24929ns
WDS	3	4332**	66/35**	6/57ns	14211ns	65158ns
Error	6	242	9/367	40/155	5199	60711
MFA	5	1171**	6/46ns	6/27ns	8210ns	130193ns
MFA×WDS	15	601**	35/414**	27/95**	14570**	193496**
Error	40	209	7/501	8/517	3959	56817
CV		7/52	10/25	14/09	41/86	20/22

* and ** significant at 5% &1% respectively, WDS: Water Deficit Stress, FA: Foliar application.

Table 2. Mean comparison of interaction between water deficit stress and methanol foliar application based on LSD 5%.

WDS	MFA	Plant height cm	Stem diameter mm	Head diametercm	Empty seed number	Full seed number
25% FC	0	168/5	20/85	15/75	123/3	674/5
	7	177/5	24/88	21/50	196/5	1136
	14	185	24/55	19/50	190/5	948/5
	21	173	28/85	22/50	64/50	1093
	28	172/5	23/80	17/50	348/5	1025
	35	170	22/60	16/25	118	1388
50% FC	0	170/5	24/95	17/50	104	1045
	7	193/5	23/15	22	222	1133
	14	190	29/20	19	90/50	1098
	21	208	28/65	24/50	151/5	1432
	28	182	25/80	20/50	86	1379
	35	170	25/15	21/50	198/5	1201
75% FC	0	153/5	28/30	23	138/5	834/5
	7	214	30	23	69/50	1569
	14	205	28/80	19	184/5	1115
	21	220	24/25	21	171	1272
	28	212	28/05	21/50	212	1361
	35	190	31/25	21/50	204/5	1125
100% FC	0	195/5	25/20	18/25	208/5	980/5
	7	211	31/45	21/50	75	1611
	14	210	34/05	24/50	110/5	1417
	21	228	22/25	26	84/50	1364
	28	216	29/75	21	138/5	869/5
	35	199	28/30	19	116/5	1232
LSD5%		20/67	3/795	4/171	89/92	340/7

WDS: Water Deficit Stress, MFA: Methanol Foliar application.

In the study on cotton, the highest plant height was observed in the treatment of 30 volumetric percentage of methanol (Makhdum et al, 2002).They expressed that methanol increasedCO_2 assimilation (Nonomura and Benson, 1992). Methanol to formaldehyde is converted by the enzyme methanol oxidase then be converted to format (Methanoeic acid). In the next step, format converted to CO_2 by format dehydrogenase, Therefore increased CO_2interacelular (Nonomura and Benson, 1992)In the study reported on cotton, spraying methanol, leads to the stimulation of growth and plant height,

by increasing cytokinin (Ivanova et al, 2000). Methylothrophyc bacteria live on the leaves of most crop plants, these bacteria, with receiving methanol provide the necessary substrate for auxin and cytokinin hormones (Ivanova et al, 2000).

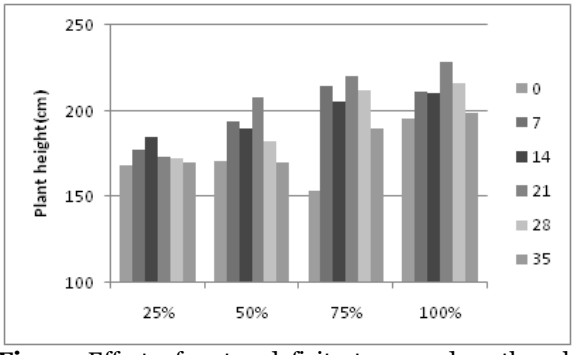

Fig. 1. Effect of water deficit stress and methanol foliar application on plant height.

Stem diameter

In normal irrigation, foliar application with 14% (v/v) methanol produced the highest stem diameter (34/04 mm) and severe stress at 0% methanol application produced the lowest stem diameter (20/85 mm); however, there was no significant difference between normal irrigation and fair stress for this trait (tab.2, fig. 2). Bayat *et al,* (2013) indicated that the number of times and time of methanol spraying on soybean had no effects on stem diameter.

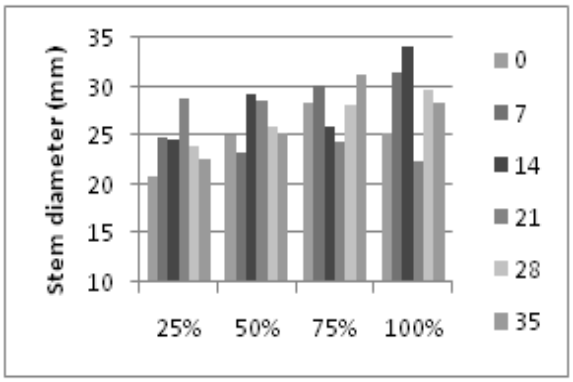

Fig. 2. Effect of water deficit stress and methanol foliar application on stem diameter.

Head diameter

The highest (26 cm) and lowest (15/75 cm) head diameter were observed for a_4b_4 and a_1b_1, respectively. This treatment had 65% more head diameter than 0% methanol foliar application for severe stress treatment (tab.2, fig. 3).

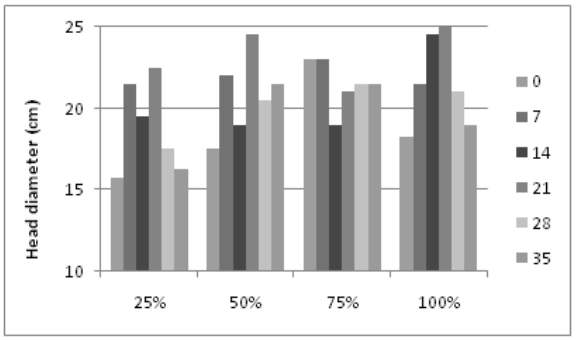

Fig. 3. Effect of water deficit stress and methanol foliar application on head diameter.

Empty seed number

A comparison of mean empty seed number revealed that the highest (248) and lowest (64/5) means were for a_1b_5 and a_4b_2, respectively (tab2, fig.4). Moghadas *et al,* (2013) reported that 15 % (v/v) methanol foliar application on barley had significant effect on number of seeds per spike. Spraying of methanol decreased damage from water stress and yield was affected by the stage of methanol application, which is in agreement with the findings of Paknejad (2012) observations.

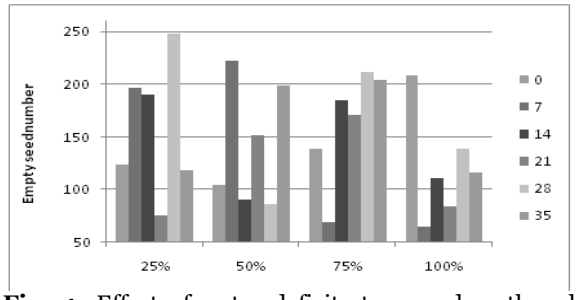

Fig. 4. Effect of water deficit stress and methanol foliar application on empty seed number.

Full seed number

The highest (1611) and lowest (674) full seed number were observed for a_4b_2 and a_1b_1, respectively. This treatment had 2 times more full seed number than 0% methanol foliar application for severe stress treatment (tab.2, fig. 3).

It seems applying methanol on water stressed sunflower plants can reduce negative impacts of drought and improve plant potential to withstand prevailing harsh and dry climate in arid areas. Sunflower morphological characteristics are affected by methanol spraying and under water deficit stress,

methanol application somewhat can reduce destructive effects of drought and prevent of yield loss. Based on the results, spraying of methanol up to 21% (v/v) had negative and poisonous effects on physiological characteristics.

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