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A study about drought stress effects on grain yield components of three sunflower cultivars

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ABSTRACT

In order to investigate the effects of drought stress on grain yield and its components, a study was carried out (2011) as split plots in randomized complete blocks design in Isfahan (32° 40' N,51° 48' E). Main factor was drought stress in four levels including irrigation after 80, 100, 120, and 140 mm evaporation from evaporation pan (class A) and subplots were three cultivars (Sirena, Record, and Euroflore).Grain number per capitulum, 1000 grains weight, grain yield, biological yield, harvest index, oil percentage, and oil yield were measured. Results showed that by increasing the stress from 80 to 140 mm, all traits except oil percentage were decreased. The first irrigation treatment (80mm) seems to be the most appropriate treatment for this plant considering the highest grain and oil yields. Record cultivar produced the highest yield under 80 and 100 mm treatments while Sirena and Euroflore had the highest yields under 120 and 140mm treatments, respectively. Therefore, cultivating record will be better under drought stress or dry farming cultivation.

Key words: sunflower, drought stress, grain number per capitulum, 1000-grains weight, grain yield

INTRODUCTION

Sunflower shows the highest sensitivity to water deficiency from formation of flower buds to full color of grains. Water stress in this time causes reduction in grain numbers and then yield reduction (Khajehpour.1991). Main components of sunflower yield are: the number of capitulum per area unit, the number of grains per capitulum, and 1000-grains weight (Hault.1984). Dihllon and Sidhu (1995) found that moisture reduction or lack of irrigation at 50% flowering caused reduction in grain yield to about 21% and also affected oil content and yield. Zafaroni and Schnider studies (1989) showed that grain number per capitulum was the most important yield component of sunflowers and must be considered for yield increasing. Saffari (2006) reported that droughts stress reduced grain numbers, grain yield, grain number per capitulum, 1000-grains weight, harvest index, and oil percentages but percentage of unfilled grains was increased. Karam et al. (2007) announced that grain yield was decreased about 25 and 14 percents by low irrigation at early and middle of flowering, but low irrigation at early stages of grain production didn't affect it. Yegappan et al. (1982) reported that drought stress caused early aging of leaves, reduction in leaves number, capitulum diameter, and leaf area and therefore grain yield of sunflower. Karam et al. (2004) reported the least dry matter accumulation with low irrigation at early and middle of flowering but said that low irrigation at early grain production didn't affect it. Chimenti et al.

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(2002) announced that drought stress had significant effect at pollination on biomass and at physiological maturity on grain yield, grain size, and harvest index. Karimizadehasl et al. (2003) observed that grain number per capitulum was reduced by effect of irrigation cycles via decrease in capitulum area. Khomri (2004) reported that drought stress at flowering stage reduced filled grained via damaging reproductive structures but water deficiency at grain filling stage caused only insufficient assimilate for grains. Human et al. (1990) concluded that drought stress at flowering and pollination stage caused the most reduction in grain yield. Abbassisiahjani et al. (2007) mentioned reduction in sunflowers biological yield due to drought stress and reported shortening of vegetative phase and reduction in photosynthetic matters as the reason of it. Sidhara and Prasad (2002) found a very good linear relationship between harvest index with growth and grain yield. They observed that grain production under drought situation was the same for similar genotypes with similar growth periods. Jafarzadehkenarsari and Poustini (1997) in a study on sunflower observed that the most sensitive stage of plant which determines grain oil percentage is grain development stage. They also found that treatments which were exposed to stress before this stage were damaged less probably because of kind of adaption. Considering various tolerances of sunflower cultivars to drought stress it is better to use tolerant cultivars which can produce the highest yield with good quality. Therefore, this study was conducted to find the effects of drought stress on grain yield and its components of three sunflower cultivars.

MATERIAL AND MTHODS

The study was conducted in 2011 as split plot in randomized blocks design with three replications. Main plots were irrigation in four levels (80, 100, 120, and 140mm evaporation from evaporation pan class A) and sub plots were three sunflower cultivars (Record, Euroflore, and Sirena). Soil preparation was done and grains were sown at June 8th. Every plot had five lines with six meter length, 60cm inter row space and 14cm distance between plants to reach to twelve plants per square meter. Needed fertilizers were used according to soil analysis test. Weeding and thinning were done at 4 leaves stage. Irrigation was done according to 80mm evaporation until plant establishment and after that irrigation treatments were enforced. To measure grain yield and yield components one square meter of each plot was harvested considering marginal effects and grain numbers per capitulum, capitulum diameter, weight of 1000 grains, plant height, stem diameter, grain yield, biological yield, harvest index, oil percentage and oil yield were measured. Oil percentage was determined using NMR method. Harvest index and oil yield were calculated from equations (1) and (2), respectivialy:

Harvest index= (grain yield/biological yield)*100 (1)
Oil yield= grain yield *oil percentage (2)

Obtained data were analyzed using MSTAT-C program. Mean comparison was done using Duncan's multiple ranges test at 5% probability level. Graphs were drawn using Excel program.

RESULTS AND DISCUSSION

The effect of irrigation treatments on grain number capitulum (table 11-4) was very significant ($p<0.01$) and the highest grain number was belonging to 80mm treatment (762.6) whereas 140mm had the least (417.5) (table 12-4). Results show that grain number was decreased by increasing the stress. Subramanian and Mahesavari (1991) found also reduction in grain number due to drought stress before flowering stage and ascribed it to reduction in flower numbers. The effect of cultivars on grain numbers was not significant, although Sirena produced the highest grain numbers (599.6) and Euroflore produced the least

(593.7). Interaction of irrigation and cultivar didn’t affect this trait and there was not an obvious trend also. Abbasisiahjani et al. (2007) didn’t observe also any significant effect of this interaction but stress increasing- especially in heading and pollination stages-reduced grain numbers. This reduction was because of decrease in capitulum area, increase in unfilled grains or interaction of them.

1000-grains weight

The effect of irrigation treatments was very significant ($p<0.01$) on 1000-grain weight (table 11-4) and 80mm treatment produced the highest weight (72.84g) whereas 140mm produced the least (43.9g) (table 12-4). Drought stress at flowering stage can reduce 1000 grains weight via reduction in transferring photoassimilates to grains. Also, this trait is dependent of genetic structure of cultivar (Rao et al.1991). The effect of cultivar on this trait was very significant ($p<0.01$) and Record produced the highest weight (59.4g) while Euroflore produced the least (58.2g). Interaction of experimental factors on this trait was significant and the highest 1000 grain weight was produced by Record cultivar in 80mm irrigation while Euroflore and 140mm irrigation had the least weight (table 13-4). Drought stress at flowering stage can cause decrease in 1000-grains weight via reduction in transferring photoassimilates. In addition, 1000-grains weight is dependent of genetic structure of cultivar also (Rao et al.1991).

Grain yield

The effect of irrigation treatment on grain yield was highly significant and 80mm treatment produced the highest yield (6634 kg/ha) whereas 140mm had the least grain yield (2199 kg/ha). Duairy and Sing (1983) mentioned that by decreasing water potential of soil to wilting point, especially in grainling and flowering stages, grain yield was reduced highly significantly. Also, Human et al. (1990) in their studies announced severe stress at flowering, pollination, and grain development stages as the reason of grain yield reduction. Stress at flowering causes falling flowers and at pollination causes reduction in fertilization and grain numbers which leads to reduction in grain yield.The effect of cultivar was not significant on this trait, however, Record had the highest yield (4414 kg/ha) and Euroflore produced the least grain yield (4312 kg/ha). The reason is higher 1000-grains weight of this cultivar in proportion to other cultivars. Interaction of experimental factors affected grain yield significantly and the highest grain yield was obtained in combination of 80mm irrigation and Record (6707 kg/ha) while severe stress (140mm) plus Sirena produced the least yield (2212 kg/ha). In study of Abbasisiahjani et al. (2007) every stress or delay in irrigation reduced this trait significantly. In their study, grain numbers had positive effect on grain yield but reduction in 1000-grains weight had negative effect on it.

Table 11-4 variance analysis of some studied traits

Source of variation	Degrees of freedom	Mean squares		
		Grain number per capitulum	1000 grain weight	Grain yield
Replication	2	1528.2	2.3	202361.2
Irrigation	3	205162.4**	1458.4**	34567234.8**
Error(a)	6	2234.5	0.1	101757.4
Cultivar	2	140.0	4.9**	37595.7
Irrigation * cultivar	6	1804.6	0.2**	76253.1*
Error (b)	16	668.8	0.10	20648.2

*and ** significant at 5% and 1% probability levels, respectively

Table 12-4 mean comparison of some studied traits

Source of variation	Grain number per capitulum	1000 grain weight(g)	Grain yield (kg/ha)
Irrigation*			
80	762.6a	72.4a	6634a
100	667.2b	65.6b	5254b
120	535.2c	53.2c	3420c
140	417.5d	43.9d	2199d
cultivar			
Sirena	599.6a	58.5b	4404a
Record	593.7a	59.4a	4414a
Euroflore	593.7a	58.2c	4312a

*(mm evaporation from evaporation pan classA)

Table 13-4 mean comparison of interaction of experimental treatments on some studied traits

Source of variation	cultivar	Grain number per capitulum	1000 grain weight(g)	Grain yield(kg/ha)
Irrigation*				
80	Sirena	759.2a	72.5ab	6589a
80	Record	765.5a	73.0a	6707a
80	Eurflore	763.2a	72.1b	6605a

100	Sirena	668.3b	65.7cd	5270b
100	Record	667.5b	66.1c	5296b
100	Eurflore	665.8b	65.0d	5197b
120	Sirena	570c	53.2f	3643c
120	Record	535.8cd	54.2e	3491c
120	Eurflore	499.8d	52.1g	3127d
140	Sirena	400.8e	43.9hi	2112e
140	Record	405.8e	44.4h	2163e
140	Eurflore	445.8e	43.4i	2321e

*(mm evaporation from evaporation pan class A)

Biological yield

Biological yield was affected by irrigation treatment highly significantly (table 14-4) and 80mm treatment produced the highest biological yield (13010 kg/ha) whereas 140mm showed the least biomass (10670 kg/ha) (table 15-4). Increase in drought stress caused severe reduction in biological yield. Results showed reductions in plant height, and stem, leaves and capitulum dry weights which these factors affected biological yield and reduced it. The effect of cultivars on this trait was very significant (table 14-4) and Record produced the highest biological yield (11800 kg/ha) while the least yield was obtained from Euroflore (11650 kg/ha) (table 15-4). Sirena and Euroflore didn't show significant difference and were located in the same statistical group.

Interaction of irrigation and cultivar didn't affect biological yield and there was not significant trend also. Brown (1977) reported decrease in biological yield by increasing irrigation cycles due to reduction in photosynthesis and transferring photo assimilates.

Harvest index

The effect of irrigation treatments on harvest index was very significant (table 14-4) and the highest harvest index was obtained from 80 mm treatment (37.62) whereas 140mm treatment produced the least harvest index (18.65).

Cultivar didn't affect harvest index significantly. However, the highest HI was obtained from Sirena (29.37) and Euroflore had the least (29.22).

Interaction of experimental factors was not significant and there was not any specific trend also. Results showed that increasing drought stress reduced both grain yield and biological yield but this reduction was more in grain yield which led to severe reduction in HI (table 16-4).

Table 14-4 variance analysis of some studied traits

Source of variation	Degrees of freedom	Mean squares			
		Biological yield	Harvest index	Oil percentage	Oil yield
Replication	2	529.8	0.09	0.06	4577.8
Irrigation	3	9720780.3**	588.3**	0.45	8031217.2**
Error(a)	6	3787.3	0.03	0.16	23927.8
Cultivar	2	80275.7**	0.08	0.25	13364.7
Irrigation* cultivar	6	2966.4	0.06	0.12	17655.9**
Error (b)	16	1768.7	0.08	0.07	5164.1

*and ** significant at 5% and 1% probability levels, respectively

Table 15-4 mean comparison of some studied traits

Sources of variation	Biological yield	Harvest index	Oil percentage	Oil yield
Irrigation*				
80	13010a	37.62a	48.11a	3192a
100	12030b	32.76b	47.90ab	2517b
120	11100c	28.10c	47.61b	1628c
140	1067d	18.65d	48.06ab	1057d
Cultivar				
Sirena	11670b	29.37a	47.96a	2113a
Record	11800a	29.26a	48.04a	2122a
Euroflore	11650b	29.22a	47.76a	2060a

*(mm evaporation from evaporation pan class A)

We can conclude that drought stress until grain maturity didn't have considerable effect on harvest index because it was decreased and various irrigation cycles were located in different statistical groups (table 16-4).

Oil percentage

The effect of irrigation treatments on oil percentage was not significant (table 14-4), however, 80mm treatment had the highest grain oil (48.11%) and 120mm treatment had the least (47.61%). According to results, oil percentage was not affected by increasing drought stress (Table 15-4). Cultivars didn't affect oil percentage but record and Euroflore produced the highest and the least percentage, respectively (48.04 and 47.76). Interaction of these factors didn't affect oil percentage significantly (table 15-4). Jafarzadekenarsari and Poustini (1997) found that seed production stage is the sensitive and oil determining stage of plant life.

Oil yield

The effect of irrigation treatments on oil yield (table 14-4) was highly significant and 80mm treatment produced the highest oil yield (3192 kg/ha) whereas 140mm had the least oil yield (1057 kg/ha) (table 15-4). Results showed that although stress didn't affect the oil percentage, it reduced the oil yield via severe reduction in grain yield. Cultivar didn't affect oil yield (table 14-4) significantly but record had the highest oil yield (2122 kg/ha) and Euroflore produced the least oil yield (2060 kg/ha). Interaction of these factors affected oil yield significantly (table 14-4) and 80mm treatment plus Record cultivar produced the highest oil yield whereas Sirena and 140mm treatment produced the least oil amount. For all irrigation treatments, Record was the top cultivar and Euroflore and Sirena were located in next places.

Table16-4 mean comparison of interaction of experimental treatments on some studied traits

Source of variation	cultivar	Biological yield	Harvest index	Oil percentage	Oil yield
Irrigation*					
80	Sirena	12990ab	37.70a	48.07ab	3167a
80	Record	13080a	37.64a	48.17a	3231a
80	Eurflore	12970b	37.53a	48.10ab	3177a
100	Sirena	12000c	32.93b	47.17a	2538b
100	Record	12100c	32.86b	48.10ab	2548b
100	Eurflore	12000c	32.50b	47.43b	2464b
120	Sirena	11070e	28.13c	47.50ab	1730c
120	Record	11210d	28.05c	47.83ab	1670c
120	Eurflore	11030e	28.11c	47.50ab	1485d
140	Sirena	10610g	18.73d	48.10ab	1016e
140	Record	10810f	18.50d	48.07ab	1040e
140	Eurflore	10600g	18.71d	48.00ab	1114e

*(mm evaporation from evaporation pan class A)

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