AgroLife Scientific Journal - Volume 3, Number 1, 2014
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

EFFECTS OF IRRIGATION HALT ON YIELD AND YIELD COMPONENTS OF THREE SUNFLOWERS (*Helianthus annuus* L.) CULTIVARS IN IRANIAN SEMI-ARID ENVIRONMENT

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Abstract

In order to study the growth and development of three irrigated sunflower hybrids (Helianthus annuus L. CVs. Zaria, Alestar and Azargol) in different irrigation halts, a field experiment was conducted at Zahedan Islamic Azad University field experiments Zahedan, Iran, in 2005. The experiment was laid out in split plot arrangement at randomized complete block design (RCBD) in 4 replications. Main plots were arranged for irrigation halt according to plant phonological stages in four levels normal irrigation or control, halt irrigation at pre anthesis, full flowering and post anthesis stages, sub plots were included three sunflower Zaria, Alestar and Azargol cultivars. The results showed halt irrigation had significant effect on all measured characters. The study of treatments interactions showed halt irrigation could reduce sunflower yield quality and quantity immediately. Azargol hybrid under flowering stage halt irrigation had the heist seed yield by 4.29 t/ha. However, Azagol cultivar was able to maintain its yield by 4.3 t/ha after halt irrigation at seed development stage. Alestar cultivar was more sensitive to halt irrigation at reproductive stages; its decreased was 48% and 45% in yield and oil yield, respectively. Zaria cultivar showed higher resistance to halt irrigation, comparing to Alestar and Azargol.

Keywords: *harvest index, irrigation halt, oil content, oil yield, sunflower.*

INTRODUCTION

Sunflower is an important oilseed crop in Iran and its production has greatly increased with the introduction of hybrids. We know that successful irrigation depends upon understanding the importance of water for Growth and development stages of plants (Hoffman et al., 1990).
Crop physiologic development is related to water received during the growing stage which is referred critical watering stop times for most irrigated crops. In sunflower irrigation should be continued until sufficient moisture is available for the sunflower seeds to fill.
The most sensitive stages of sunflower (*Helianthus annuus*) to limited water are flowering and seed maturity (Chimenti et al., 2002). Sunflower's water demand in a single growth period is about 500 mm per hectare (Khajae-Pour, 2004; Aleyari and Shekari, 2000). Moisture deficiency from budding to the end of flowering period has the most adverse effect on the yields of sunflower hybrids (Pankovic et al., 1999).
Drought stress always adversely affects head diameter (Mozaffari et al., 1996). Vilalobos et al. (1996) stated that drought stress brought about early leaf senescence, and the decrease in leaf number, head diameter, leaf area and grain weight and as a result, grain yield in sunflower.
Irrigation of sunflower during budding increases vegetative growth and decreases water use efficiency. But irrigation during germination and flowering had the highest water use efficiency (Unger, 1992).
Irrigation during budding transfers nutrients to budding and final irrigation causes optimum filling of sunflower grains.
No-irrigation during soft dough stage can decrease grain yield by 25% (Dihllon and Sidhu, 1995). Roshti et al. (2005) found that water deficit stress decreased grain yield and the treatment of irrigation after 70.0 mm evaporation produced the highest grain yield (5125 kg) whereas the treatment of irrigation after 110 mm evaporation produced the lowest

one. However, a harvest index (HI) had significant varies from no water limitation to halt irrigation after vegetative growth stage (Hoffman et al., 1990).

Our aim was to measure the effects of halt irrigation on sunflower cultivars at Iranian environment, and more especially of halt the irrigation and water stress during seed formation and seed development stages to maturation, on seed yield and especially on the yield components.

MATERIALS AND METHODS

In order to study of halt irrigation on yield and some plant characteristics of three sunflowers cultivars (*Helianthus annuus*), a field experiment was conducted at the semi arid farm research station of Zahedan Islamic Azad university (25.28 N latitude, 60.53 E longitude and 1370 meter above sea level altitude) Zahedan, Iran at 2005.

The climate of this region is semi-arid with average annual precipitation of 55 mm. March to July average precipitation was approximately 0.52 mm. The soil type in the plot area is sandy - loam and is well drained.

The gravimetric water content at the field capacity, wilting point and available water holding capacity of the soil are shown in Table 1.

The electrical conductivity (EC) of the irrigation water was 2.0 dsm^{-1} and the sodium absorption ratio (SAR) was 10.2. In addition, the averages of temperature, relative humidity, average evaporation, average precipitation, wind speed and sunshine duration per day during the growth season are listed in Table 2.

The experiment was laid out in split plot arrangement with randomized complete block design (RCBD) with 4 replications.

There were four levels for irrigation (complete irrigation or control, halt irrigation at seed development, flowering end and flowering start of sunflower growth and development stages) in main plots and three sunflower cultivars (*Helianthus annuus* L. cv. Zaria, Alestar and Azargol) in sub plots. Three sunflower cultivars were grown on a soil with supplementary irrigation.

Table1. Soil properties in the experimental site at the start of the study (2005)

Soil depth (cm)	0-30	30-60
Bulk density (g cm^{-3})	1.12	1.22
Field capacity (%)	18.60	21.20
Wilting point (%)	14.10	15.60
Available water holding capacity (mm 30 cm^{-1})	49.30	51.20
Total N (%)	4.30	6.10
pH	8.00	8.00
P_2O_5 (ppm)	4.70	5.20
K_20 (ppm)	2.50	2.50
Organic matter (%)	0.02	0.02
$CaCO_3$ (%)	52.00	69.00

The cultivars were sown in 10 May with 10 plant m^{-2} density. The hybrids were selected based on performance in yield and oil yield across Iran environments.

A plot size included 6 rows in 6.0 meters and inter-row spacing of 1.0 meter was used. The sunflower penology was followed from Flowering first or time of start the flowering stage in the cultivars, full flowering stage and seed development (grain samples were collected every 5 days from the intermediate of the floral discs, dried at 70 °C for 48 hours, and weighed) (Ploschuk and Hall, 1995). Yield was determined by hand harvesting at physiological maturity of 4.0 m^2 (two central rows).

Grain oil percent was determined by nuclear magnetic resonance (Granlund and Zimmerman, 1975). Plant height, 1000 seeds weight and harvest index were determined for all 48 plots.

Table 2. Some environmental characteristics of the study site (2005)

Period	Mean daily					
	Temperature (°C)	Relative humidity (%)	Evaporation (m)	Precipitation (mm)	Wind speed (m s-1)	Sunshine duration (h)
March	14.60	53.0	3.64	2.11	10.00	5.95
April	18.40	44.5	8.14	0.25	7.97	9.79
May	23.10	51.5	10.37	0.31	11.68	9.82
June	26.25	32.5	11.16	0.07	10.58	10.86
July	30.10	15.5	15.11	0.00	10.21	11.56

RESULTS AND DISCUSSIONS

According to Table 3, at harvest time, plant height, number of grain per head, 1000 grain weight, grain yield, oil yield and harvest index were significantly affected by irrigation regimes and cultivar types and interactions.

But oil percent was not affected by cultivars type significantly at 5% of level. And also the interaction of treatments for oil grain content, plant height and number of grain per head were no significant.

The results show that, when irrigation regimes were completely or none halt, yield components and grain yield had the best records. The interaction between irrigation and cultivars significantly affected grain yield (Table 3). Means comparison data showed the treatment of Azargol and normal irrigation produced the highest grain yield by 5.70 t/ha. Pre-anthesis halt irrigation and Zaria (I_2C_1) produced the lowest grain yield by 2.8 t/ha (Table 4).

The grain yields of Azargol was much more than others by 4.30 t/ha. We don't distinguish any statistical differ between Zaria and Alestar in relation to upon characteristics; those are in same grouping according to Duncan multiple range at 5% level.

As a final point and by the study of interactions of treatments we can verify that under incomplete irrigation in semiarid location the quality and quantity of sunflower yield just about interconnected with adaptation of cultivars and generally supply the water for plants at the middle of the reproduction stage mostly full flowering stage. Our results were consistent with previous work which demonstrated a strong oil content reduction with a water deficit from anthesis to maturity (Champolivier and Merrien, 1995). The analysis of variance for single effect of irrigation treatment and also cultivar treatment separately, was significant for grain number per head at 1% and 5% probability level respectively (Table 3).

Means comparison for average grain numbers per sunflower heads showed the highest record was obtained in normal irrigation by 847 (I_1) and Post-anthesis stage halt irrigation by 856 (I_4) which ranked in the same statistical group.

Zaria (C_1) cultivar also had the highest number of grain per head by 858.

The treatment of Pre-anthesis halt irrigation had the lowest filled grain number per head (708).

Under critical halt irrigation conditions, head diameter and grain number considerably decrease (Aleyari and Shekari, 2000).

Water deficit occurrence during sunflower flowering stage dehydrates pollens and pistils which in turn, interrupts pollination by insects and the dehydration of stigmata of pistils sticks pollens to stigmata, prevents germination of pollens on stigmata and finally, decreases fertile and filled grain number/head (Mozaffari et al., 1996).

Valad-Abadi et al. (2008) showed that with the intensification of stress from 50 mm to 150 mm, filled grain number per head decreased from 750.1 to 475.1.

Table 3. Summary of analysis of variance for effect of halt irrigation and sunflower cultivars

S.O.V	D.F	Mean square						
		Grain yield	Oil yield	Oil content	Plant height	No. grain per head	Grain weight	HI
Replication	3	0.42 ns	0.01ns	25.18 ns	217.80 ns	18734.00 **	1.20 ns	156.1 ns
Irrigation halt(I)	3	6.01 **	1.52 **	56.14 *	852.00 **	55127.00 **	501.10 **	3321**
Error1	9	0.31	0.09	8.42	59.35	2508.00	53.13	312.9
Cultivar(C)	2	2.88 **	0.56 **	3.07 ns	2781.00 **	45059.00 *	738.70 **	4552 **
Interaction(I.C)	6	0.63 *	0.16 *	3.22 ns	161.20ns	20419.00 ns	79.70 **	767 *
Error 2	24	0.24	0.05	3.91	193.00	10773.00	13.66	246.2
C.V%		12.88	15.14	5.08	11.96	12.93	7.70	15.26

**significant differences at P%<0.01 level, *significant differences at P<0.05 level and ns: Non-significant

Table 4. Mean comparisons for grain yield, yield components and harvest index

Treatments	Grain Yield (t/ha)	Oil Yield (t/ha)	Grain oil Content (%)	Plant Height (cm)	No grain per head	1000 Grain weight (g)	HI%
I1	4.70 a	1.98 a	41.98 a	125 a	847 a	56.90 a	40 a
I2	3.25 c	1.26 c	38.65 b	104 c	708 c	45.60 bc	32 c
I3	3.27 c	1.21 c	36.97 b	117 b	796 b	41.24 c	38 b
I4	4.13 b	1.55 b	38.02 b	118 b	856 a	48.60 b	39 ab
C1	3.46 b	1.35 b	38.95 a	125 a	857 a	40.50 c	37 b
C2	3.75 b	1.45 b	38.44 a	101 a	751 b	49.70 b	35 b
C3	4.29 a	1.71 a	39.31 a	123 a	800 ab	53.80 a	41 a
I1C1	3.90 bcd	1.60 bcd	41.00 a	136 a	922 a	42.00 d	40 ab
I1C2	4.50 b	1.85 b	41.00 a	101 a	726 a	61.60 a	42 bc
I1C3	5.70 a	2.50 a	43.40 a	127 a	894 a	66.20 a	46 a
I2C1	2.80 f	1.10 d	38.80 a	115 a	673 a	42.30 d	29 d
I2C2	3.50 cdef	1.30 cd	38.40 a	96 a	739 a	45.50 cd	28 d
I2C3	3.40 cdef	1.30 cd	38.70 a	104 a	714 a	49.20 bc	35 b
I3C1	3.00 ef	1.10 d	36.50 a	127 a	903 a	33.60 e	32 bc
I3C2	3.10 def	1.20 cd	37.20 a	97 a	701 a	43.90 cd	37 b
I3C3	3.70 bcde	1.40 bcd	37.20 a	128 a	786 a	46.20 cd	38 b
I4C1	4.10 bc	1.60 bcd	39.30 a	132 a	928 a	44.30 cd	39 b
I4C2	4.00 bc	1.50 bcd	36.80 a	100 a	836 a	47.80 cd	41 b
I4C3	4.30 b	1.70 bc	38.00 a	126 a	807 a	53.60 b	43 a

Data by different letters indicate statistically significant differences using Duncan Multiple range at P %<0.01. I_1 to I_4 and C1to C_3 treatments are characters for Normal irrigation (I_1), Pre-anthesis halt irrigation (I_2), Flowering stage halt irrigation (I_3), Post-anthesis stage halt irrigation (I_4), and Zaria (C_1), Alestar (C_2) and Azargol (C_3) for sunflower.

On the other hand, since the formation of central floret of head is initiated at 8-12 leaf stage, any kind of water stress at this stage can cause the decrease in floret number per head (Aleyari and Shekari, 2000) and filled grain number per head.

Irrigation halt had significant effect on oil content at 1% probability level (Table 3). The treatment of normal irrigation had the highest oil content by 41.98% and the least were 38.65, 36.97 and 38.02% for I_2 to I_4 which ranked in the same statistical group.

The increase in oil content of sunflower grains requires a prolonged growth period, especially from flowering until grain filling. Our results previous reported which demonstrated that a strong oil content reduction with a water deficit from anthesis to maturity (Champolivier and Merrien, 1995).

The lowest harvest index close to 32.00% was for irrigation regime that blocked at pre-anthesis phase as a key result of this research. In this assessment the Azargol hybrid of sunflower is indication for Grain and oil yield, oil percent, plant height, 1000 grain weight and finally harvest index.

The grain yields of this hybrid was much more of others by 4.30 t/ha yield, by means that over 1.55 t/ha adding up and with 41% harvest index means 4-6% more of Zaria and Alestar respectively (Table 4). We do not distinguish any statistical differ between Zaria and Alestar in relation to upon characteristics; those are in same grouping according to Duncan multiple range at 5% level.

CONCLUSIONS

As a final point and by the study of interactions of treatments we can verify that under incomplete irrigation in semi-arid Iranian environments the quality and quantity of sunflower yield just about interconnected with adaptation of cultivars and generally supply the water for plants at the middle of the reproduction stage mostly full flowering stage.

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