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Evaluation of deficit irrigation management, nitrogen levels, and seed priming simultaneously, on some properties of hybrid sunflower *(Helianthus annuus)*

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Abstract

Sunflower (*Helianthus annuus* L.), one of the world's leading oilseed crops, was investigated for its properties in response to deficit irrigation, nitrogen levels, and seed priming. The end points were: Biological yield, oil yield and water use efficiency (WUE). For this purpose, a randomized block experiment design with split-split plot arrangement with four replicates was established. The overall results obtained in this study indicate that different level of nitrogen, time of irrigation, seed priming and their interaction had significantly affected on biological yield and WUE ($p \leq 0.01$). Also, different level of nitrogen and time of irrigation had significantly affected on biological yield ($P \leq 0.05$ and $p \leq 0.01$), respectively. But, seed priming and their interactions had no significant effect on this trait. Treatment of $I_4N_3Pt_3$ had the most WUE (3.02 kg/m^3). Pre-treatment mono ethanol amine had the most effect on biological yield. The using of mono ethanol amine in I_4Pt_3 could prevent the decrease of biological yield (from 40.21 to 7.43 %) due to drought stress in comparison with I_4Pt_1. Investigation of project's results shows that pre-treated sunflower plant by mono ethanol amine decrease the damages but it to be repeated by more researches for better announcement.

Keywords: biological yield, Nitrogen, oil yield, Sunflower, Water use efficiency (WUE).

Introduction

Sunflower (*Helianthus annuus* L.), one of the world's leading oilseed crops, is mainly cultivated for its oil. Non-oilseed sunflower (confectionary) with lower oil content is mainly consumed in the domestic market, such as in snack or bakery foods (Goksoy *et al*., 2004; Kiani *et al*., 2007). Like most oilseeds, sunflower has a potential utility for many industries. Different products can be obtained from crude oil, cake, hulls or refined oil, including plastics, lecithin, or emulsifying agents (Taiz & Ezeiger, 1991; Aguirrezábal & Pereyra, 1998). In the last few years, sunflower oil has also gained special recognition based on non-food purposes. Its use as biodiesel, or as vegetable-oil based fuel for many vehicles, including farming equipment is feasible (Pereyra-Irujo et al., 2009). Genetic improvement and the emergence of new industrial processes make it possible to implement these potential uses. Most of the oil is accumulated in the kernel (shelled seed) and only 3–5% is located in the pericap, also known as "hull" (Connor & Sadras, 1992). The oil concentration is determined by genetic factors, but it can be modified by the environment and growth conditions. Usually, black hull hybrids produce fruit (seeds) with an oil concentration higher than striped hull hybrids (Izquierdo et al., 2008). It is common to find mixture of hybrids (seeds of black and striped hull) as feeding in the dehulling process. In order to improve equipment handling and to optimize oil yield, it would be necessary to know the differential characteristics of these hybrids. A few reports on moisture-dependent physical properties of sunflower seeds have been published. Gupta and Das (1997) analyzed the physical properties of a sunflower variety grown in India (Morden) (Gupta & Das, 1997), (Santalla & Mascheroni 2003) studied a striated high oleic sunflower hybrid cultivated in Argentina, but no bibliography has been found about a comparison among sunflower hybrids of different structural characteristics (Santalla & Mascheroni, 2003). Irrigation is one of the most important limiting factors of the agricultural production during the hot and dry periods (Dagdelen *et al*., 2006). Sunflower oil contains large amount of A, D, E, K vitamins and considerable proteins (20-40%) (Connor & Hall, 1997; Aerts & Chapin, 2000). By fertilizing and increasing the soil fertility, the seed yield and its oil content are increased (Egli, 1998; Sudhakar *et al*., 2003; Sharma *et al*., 2002). Simultaneous decrease of oil percentage and increase of nitrogen levels have been reported by many researchers (Tomar *et al*., 1997; Janssen, 1998).The present study aims for evaluation on deficit irrigation, nitrogen levels, and seed priming simultaneously for hybrid sunflower (*Helianthus annuus*). The properties evaluated were: Biological yield, oil yield and Water use efficiency (WUE).

Materials and methods

A randomized block experiment design with split-split plot arrangement with four replicates was established in

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the research farm of the Islamic Azad University, Varamin-Pishva branch, Tehran, Iran. Each plot included 7 planting lines (distance between lines was 60 cm), length of each line was 2 m and also distance in-row was 20 cm. The soil was classified in loam-clay. After soil experiment, seeds were planted in two depths include 0-30 cm and 30-60 cm as furrower method and then were irrigated immediately. Protections were achieved accordance routine agronomic methods. All treatments were irrigated three times in order to homozygous germination and the used water was calculated by contour during the growth season. In order to calculation of irrigation depth, soil samples selected from depths 0-30 and 30-60 cm. the humidity percentage of soil was calculated and then the needed water to reach to field capacity was measured. Also soil was fertilized with nitrogen fertilizer in two times include pre-planting (1/3) and post-thinning (2/3).

Table1. Characteristics of irrigation treatments

Treatment	No. of irrigation	Used water (m^3/ha)
I_1	13	8563.492
I_2	11	7246.031
I_3	11	7246.371
I_4	9	5928.571

Experimental treatments include irrigation levels in four levels:

I_1: perfect irrigation, I_2: no irrigation from budding to flowering, I_3: no irrigation from flowering to grain filling and I_4: no irrigation from budding to grain filling stage as main factor (drought stress in phonological stages of plant) and used nitrogen in three levels of 0, 90 and 180 kg/ha as marginal factor.

Seed priming in three levels of Pt_1: no pre-treatment, Pt_2: soaking seeds in distilled water for 24 hours and Pt_3: soaking seeds in mono ethanol amine for 6 hours as sub-sub factor.

Water used and times of irrigation show in Table 1. Some meteorological properties of studied area show in Table 2. The properties evaluated in this study were biological and oil yield and water use efficiency. The data obtained from field measurements and laboratory observations were collected to analysis with statistical comparison of averages, using the Duncan's multiple range test method with MSTATC software.

Table 3. Variance analysis on measured characters (MS)

s.o.v	df	Biological Yield (kg/ha)	Oil yield (Kg/ha)	Water use efficiency (kg/m^3)
R	3	2637743.065	131301.331	0.045
I	3	191956786.446**	1865236.24**	0.434 **
a	9	2483046.533	43165.118	0.049
N	2	71345681.993**	950517.747*	1.364* *
I.N	6	50160267.999**	167783.811 ns	0.964**
b	24	6361546.406	220653.337	0.144
Pt	2	43824071.066**	215682.451 ns	1.153**
I.Pt	6	47975140.160**	127179.568 ns	0.945**
N.Pt	4	28709921.177**	227202.863 ns	0.698**
I.N.Pt	12	27002002.628**	132377.605 ns	0.614**
c	72	8798054.510	115937.489	0.168
c.v%	-	20.58	24.57	20.62

*ns. no significant; **.Significant at 0.01; *. significant at 0.05.*

Table 2. Meteorological properties of studied area

Wind speed (km/hr)	Evaporation (mm)	rainfall (mm)	RH (%)	Sun hours (Hour)	Min mean temperature (°C)	Max mean temperature (°C)	Annual mean temperature (°C)	factors
12.16	292.16	1.13	33.16	318.66	18.35	34.63	26.5	mean

Results and discussion

Biological yield

According to Table 3, different level of nitrogen, time of irrigation, seed priming and their interaction had significantly affected on biological yield with confidence interval of 99% ($p \leq 0.01$). Also, minimum and maximum amount of biological yield was obtained in $I_4N_1Pt_2$ and $I_2N_1Pt_3$ treatment, respectively that implied decreasing trend of shoot weight (stalk, leaf and head), leaf area and photosynthesis crops production resulted from limited water during phonologic stages (Table 4). Also, trend of changes shows that biological yield in treatment of I_2 was decreased 6.42% in comparison to I_1. Also biological yield in treatment of I_3 and I_4 was decreased 15.43% and 31.95% in comparison to I_1, respectively. With increasing the used nitrogen (from 90 to 180 kg/ha) biological yield was increased too.Similar letters show there isn't any significant difference between treatments

Oil yield

Grain oil yield is one of the most important traits in sunflower (grain oil yield= grain oil percentage * grain yield). Obtained results from Table3 show that different level of nitrogen and time of irrigation had significantly affected on oil yield with confidence interval of 95% and 99% ($P \leq 0.05$ and $p \leq 0.01$), respectively. But, seed priming and their interactions had no significant effect on this trait. The maximum and minimum amount of oil yield (2003 and 713.51 kg/ha) achieved in $I_1N_3Pt_1$ and $I_4N_1Pt_1$ treatments, respectively. Oil yield in I_2 increased 5.46 % toward I_3. Also, minimum and maximum amount of oil yield achieved in 0 and 180 kg N/ha.

Water use efficiency (WUE)

According to Table 3, different level of nitrogen, time of irrigation, seed priming and their interaction had significantly affected on WUE with confidence interval of 99% ($p \leq 0.01$). The maximum WUE were obtained in $I_4N_3Pt_3$ (3.02 kg/m^3), $I_2N_3Pt_3$ (2.80 kg/m^3) and $I_3N_2Pt_3$ (2.78 kg/m^3) whereas, the lowest WUE (1.18 kg/m^3) have been reported in $I_4N_3Pt_2$ (Table. 4).

Conclusion

The overall results obtained in this study indicate that different level of nitrogen, time of irrigation, seed priming and their interaction had significantly affected on biological yield and WUE with confidence interval of 99%

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(p≤0.01). Also, different level of nitrogen and time of irrigation had significantly affected on biological yield with confidence interval of 95% and 99% (P≤0.05 and p≤0.01), respectively. But, seed priming and their interactions had no significant effect on this trait. Also, results showed that simultaneously utilizing the N_3 (180 kg/ha) and I_1 resulted to decreasing of damage on yield in comparison with other treatments in sunflower. $I_4N_3Pt_3$

Table 4. The effects of triple interaction treatments on measured characters

Factor	Biological Yield (kg/ha)	Oil yield (Kg/ha)	Water use efficiency (kg/m^3)
I1N0Pt1	16740 ABCDEFG	1261.BCDEFGHI	2.160 BCDEFGH
I1N0Pt2	17290 ABCDEF	1380BCDEFGH	2.232 BCDEFGH
I1N0Pt3	13700CDEFGHIJ	1373BCDEFGH	2.009 DEFGHI
I1N90Pt1	18710 ABC	1598.ABCDEF	2.184BCDEFGH
I1N90Pt2	14770 BCDEFGHI	1330BCDEFGH	1.725 EFGHIJK
I1N90Pt3	13890 CDEFGHIJ	1505 ABCDEF	1.621 GHIJK
I1N180Pt1	18490ABCD	2003.A	1.955 DEFGHI
I1N180Pt2	19110AB	1990.A	2.019 DEFGHI
I1N180Pt3	17200ABCDEFG	1510.ABCDEF	1.599 HIJK
I2N0Pt1	13510 DEFGHIJK	1451.ABCDEF	1.828 EFGHIJK
I2N0Pt2	16150ABCDEFGH	1405.BCDEFG	2.767 ABC
I2N0Pt3	20300 A	1716.ABC	2.322 BCDEFG
I2N90Pt1	14920 BCDEFGHI	1504.ABCDEF	2.060 DEFGHI
I2N90Pt2	13050EFGHIJK	1496.ABCDEF	1.800 EFGHIJK
I2N90Pt3	12190 FGHIJK	1480.ABCDEF	1.682 FGHIJK
I2N180Pt1	13250 EFGHIJK	1720.ABC	1.865 DEFGHIJK
I2N180Pt2	20050 A	1382BCDEFGH	2.229 BCDEFGH
I2N180Pt3	16830ABCDEFG	1747.AB	2.802 AB
I3N0Pt1	8850 JKL	1061EFGHI	2.007 DEFGHI
I3N0Pt2	10160 IJKL	1247BCDEFGHI	1.904 DEFGHIJ
I3N0Pt3	11570 HIJKL	1142CDEFGHI	2.545 ABCD
I3N90Pt1	12270 FGHIJK	1306BCDEFGH	1.693 FGHIJK
I3N90Pt2	16940ABCDEFG	1431ABCDEFG	2.337 BCDEF
I3N90Pt3	20140 A	1665ABCD	2.780 ABC
I3N180Pt1	14550 BCDEFGHI	1654ABCDE	1.221 JK
I3N180Pt2	13800 CDEFGHIJ	1375BCDEFGH	1.403 IJK
I3N180Pt3	18440ABCD	1585ABCDEF	1.596 HIJK
I4N0Pt1	8479 KL	713.5I	1.900 DEFGHIJ
I4N0Pt2	7048 L	849.3GHI	2.045 DEFGHI
I4N0Pt3	17950ABCDE	1553.ABCDEF	2.429 ABCDE
I4N90Pt1	12500 FGHIJK	1101DEFGHI	2.108 CDEFGHI
I4N90Pt2	9124 JKL	810.5HI	1.539 HIJK
I4N90Pt3	9113JKL	1045FGHI	1.537 HIJK
I4N180Pt1	11260HIJKL	1186BCDEFGHI	1.430 IJK
I4N180Pt2	12120 GHIJK	1171.BCDEFGHI	1.189 K
I4N180Pt3	14400 BCDEFGHI	1150BCDEFGHI	3.027 A

had the most WUE (3.02 kg/m^3). Pre-treatment mono ethanol amine had the most effect on biological yield. The using of mono ethanol amine in I_4Pt_3 could prevent the decrease of biological yield (from 40.21 to 7.43 %) due to drought stress in comparison with I_4Pt_1. Investigation of p0roject's results shows that pre-treated sunflower plant by mono ethanol amine decrease the damages but it to be repeated by more researches for better announcement.

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