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Response of new sunflower genotypes to water stress and super absorbent

A. Zareei Siahbidi[1*], E. Majidi Hervan[2], A. Naderi[3], S. Lack[4], S. Sasani[5]

[1]*Department of Agriculture Management, College of Agriculture, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran*

[2]*Agriculture Biotechnology Research Institute of Iran (ABRII), Karaj, Iran*

[3]*Seed and Plant Improvement Department, Agriculture and Natural Resources Research Center, Khuzestan, Iran*

[4]*Department of Agriculture Management, College of Agriculture, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran*

[5]*Seed and Plant Improvement Department, Agriculture and Natural Resources Research Center, Kermanshah, Iran*

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Abstract

To evaluate effects of water stress and super absorbent polymer (A200) on some qualitative and quantitative traits of sunflower genotypes, a split-factorial experiment was carried out as Randomized Complete Block Design (RCBD) with three replicates on Eslamabad–e-Gharb Agricultural Research Station during 2011 and 2012. Factors were water stress in three levels (irrigation in 25%, 50% and 75% depletion of the soil moisture) and super absorbent polymer in three levels (0, 100 and 200 kg/ha) and three sunflower genotypes (Farrokh, Ghasem and SHF81-90). In this experiment seed yield and yield components were investigated. The results showed that the highest (6337 Kg/ha) and the lowest (2601 Kg/ha) seed yield were obtained at full irrigation with SHF81-90 and full stress with Ghasem, respectively; hence, SHF81-90 at full irrigation is superior and Farrokh at water stress condition is inferior genotype. On the other hand, polymer application increased the yield and yield components on all genotypes

* **Corresponding Author:** Asadolah Zareei Siahbidi ✉ azareei46@gmail.com

Introduction

Drought and its resultant stress is one of the most common environmental stresses that globally limited agricultural production and reduces land use efficiency (kordovani, 1997). The climate of Iran is arid to semi-arid, and water stress is one of the most problems in crop production. Oil seeds are the most important global food supply behind Cereals, Sunflower (*Heliantus annuus* L.) is one of the major sources of edible oil in the world, that covers 7 % of the total oilseeds production of the world (FAO, 2011). Sunflower (*Helianthus annuus* L.) is one of the most important oil crops and due to its high content of unsaturated fatty acids and a lack of cholesterol, the oil benefits from a desirable quality (Razi and Asad, 1998). Nazarli and Zardashti (2010) reported that irrigation at the flowering stage increases the seed yield by more than 60% in comparison to the control. In an experiment on 14 sunflower cultivars, Razi and Asad (1998) indicated that irrigation has resulted in an increase in Head size, stem diameter, plant height, 1000-seed weight and seed yield. Safari (2006) reported that water stress reduced grain numbers, Seed yield, grain number per head, 1000-grains weight, but percentage of unfilled grains was increased. Abolhasani and Saeedi (2004) evaluated 15 genotypes of sunflower in two irrigation regimes based on 50 and 85% depletion of soil moisture content and observed that the highest positive correlation between measured variables and yield was related to seed number per Head, plant height and days to maturity, seed number was the most important criterion for yield improvement in either stressed or non-stressed conditions.Super absorbent A200 polymers are made of hydrocarbon. These materials can absorb and retain water, several times of their weight. When the environment dryness occurs, the polymer gradually releases water so the moisture is retained in the soil for a long-time without needing for a renewed irrigation. Thus, application of hydrophilic polymers can result in significant reduction of the required irrigation frequency particularly for sandy soil. This is an important problem in arid and semi-arid regions, where the irrigation water is a scarce commodity and a short-term drought can cause plant losses. Thus, the cost of irrigation and water saving must be minimized (Fazeli *et al.,* 2012).

Kermanshah (The implementation of esearch) is located on arid and semi-arid regions of Iran, so determination of new sunflower hybrids response at this conditions and identification of tolerant and efficient water use line is importance. Because, Department of Oilseeds Research, runs breeding projects annually to evaluate and release the new sunflower hybrids, studies based on their tolerance to environmental stresses in different climatic conditions, seems to be necessary. Although, many researches have been done on water stress and super absorbent polymers application, due to climate changes and its impacts on agriculture and crop production, and also different reactions of super absorbent in different soils, reaction evaluation of new sunflower hybrids to drought stress and deficit irrigation on current project was done to identify the most tolerant sunflower hybrids.

The aim of this study was to study the effects of the various levels of water stress and super absorbent polymer (A200) on seed yield, head diameter, seed weight and **s**eedper headon new sunflower genotypes.

Materials and methods

Location and date

The trials were conducted at 2010 and 2011 cropping seasons at the Eslamabad–e-Gharb Agricultural Research Station in Kermanshah province, Iran (latitude 34°8'N and longitude 47°26'E) at the silty clay loam soil texture.

Experiment design

Experiment was carried out as spilt factorial based on Randomized Complete Block Design (RCBD) with three replicates. Irrigation strategy and super absorbent application were allotted to main plots. Irrigation strategy had three levels: (irrigation in 25, 50 and 75% depletion of the soil moisture).

Water measurement and treatment application

Soil moisture meters measured by gypsum blocks were used to determine the moisture depletion level in the soil. The gypsum blocks were buried at 25 cm depth, and soil moisture meters were used to measure the soil moisture content. Super absorbent application had two levels: (100 and 200 kg/ha, compare to non-application as check) and three sunflower genotypes (Farrokh, Ghasem and SHF81-90) were allotted to sub plots. The soil amendment used was a hydrophilic polymer, Superab A-200 produced by Rahab Resin Co. Ltd., under license of "Iran Polymer and Petrochemical Institute". The chemical structure of Superab A200 is shown in Table 1 (Fazeli *et al.,* 2012). Before seed (*Helianthus annuus* L.) planting, due to location of most roots in depths of 7-10 centimeters, Super absorbent A-200 was placed by hand at the same depth along the row ridges (Fazeli *et al.,* 2012). Sunflower seeds were planted in five rows of 5 m with 60 cm line interval and 20 cm bush interval on May 9th. 2010 and also 2011. During the growth season, hand weeding was done by necessity. On harvest time, the traits were measured including Seed yield and its components.

Data analysis

Collected data for each parameter, were subjected to analysis of variance (ANOVA) using the SAS software (SAS Release 9.2, SAS Institute Inc., Cary, NC, USA). Where the F-ratios were found to be significant, treatment means were separated using the Fisher's Least Significant Difference (LSD) at P ≤0.05.

Results and discussions

Seed yield

Seed yield of all genotypes were affected by water deficit, super absorbent and genotypes. Seed yield was significantly higher in SHF81-90 (4541 kgha^{-1}) than Farrokh (4393 kgha^{-1}) and Ghasem (4271 kg ha^{-1}) (Table, 2). The reason is higher 1000-grains weight of this genotype in proportion to other genotypes. Moreover, the interaction between water deficit and genotype had significant difference at p<0.01 and interactive effect between super absorbent and genotype had significant difference at p<0.05. The highest and the lowest Seed yield were obtain from full irrigation and SHF81-90 genotype (5911 kgha^{-1}) and full stress and Ghasem genotype (2794 kg ha^{-1}), respectively (Table, 2). Trend of changes show that moderate stress in comparison with full irrigation and full stress to full irrigation decreases 24% and 53% the Seed yield, respectively. Duairy and Sing (1983) mentioned that by decreasing soil water potential to wilting point, especially in graining and flowering stages, Seed yield was reduced significantly.

Table 1. The properties of Super absorbent (A-200).

Appearance	White granule
Grain size (i m)	50-150
Water content (%)	3-5
Density (g cm-3)	1.4-1.5
Acidity (pH)	6-7
The actual capacity of absorbing	1-2
the solution of 0.9% NaCl	45
The actual capacity of absorbing top water	190
The actual capacity of absorbing distilled water	220
Maximum durability (year)	7

Super absorbent also caused significant difference on Seed yield among genotypes. Seed yield at the control plots was 4313 kg but treated plots with 100 and 200 kg , were 4395 kg and 4498 kg respectively (Table 2).Therefore, the treated super absorbent 100 and 200 kg per hectare, enhanced 2 % and 3.4% respectively, more than control. It seems that adequate water available and nutrient mobilization facilities were the main reasons for grain weight increase under polymer treatment. The results showed that SHF81-90 (4541 kg of grain per hectare) had 3.4 % and 6.3 % yield increase in compression to Farrokh (4393 kg/ha) and Ghasem (4271 kg/ha), respectively (Table 2).

Table 2. Effects of different water stress levels, and genotypes on seed yield, head diameter, seed weight and Seed per head of new sunflower genotypes.

Treatment	Seed yield	Head diameter	Seed weight	Seed per Head
water stress				
Full irrigation	5911	17.49	68.68	1125
Semi Stress	4499	15.08	62.21	909
Full stress	2794	13.77	58.74	624
LSD (p≤ .05)	*131*	*0.47*	*3.47*	*3.83*
super absorbent rate (kg ha-1) wewwwewewe				
0	4313	14.08	61.45	806
100	4395	15.40	64.61	879
200	4498	16.86	68.57	905
LSD (p≤ .05)	*102*	*1.32*	*3.16*	*26.70*
genotype				
Farrokh	4393	15.31	61.28	933
Ghasem	4271	15.18	63.75	835
SHF81-90	4541	15.80	65.59	890
LSD (p≤ .05)	*221*	*0.35*	*1.87*	*11.58*

The main reason for approaching the similar average Seed yield of genotypes, was Seed yield reduction of SHF-81-90 and its extreme sensitivity to water stress and also better resistance of Farrokh and Ghasem face to mentioned condition. Evaluation of reaction treatment showed thatby improving after stress and decrease of soil water, genotypes reaction were different and Seed yield reduction on Farrokh, Ghasem and SHF81-90 were 33%, 40% and 41% respectively. It seems that Farrokh is more tolerant genotype under stress condition. These results are consistent with research reports of the Esmaeilian*et al* (2012) and Darvish Zadeh *et al* (2011).The most (4648 kg/ha) and the least(4195 kg/ha) seed yield were obtainedbySHF81-90 and Ghasem by application200kg/ha super absorbent versus control, respectively (table 5).

Table 3. Interaction effects of water stress levels and genotypes on Seed yield, head diameter, seed weight and Seed per head of new sunflower genotypes.

Treatment	Genotype	Seed yield	Head diameter	Seed weight	Seed per Head
water stress					
Full irrigation	Farrokh	5524	17.05	64.42	1122
	Ghasem	5873	16.97	68.47	1122
	SHF81-90	6337	18.47	73.16	1133
Semi stress	Farrokh	4583	15.03	62.95	970
	Ghasem	4340	14.75	66.40	839
	SHF81-90	4576	15.48	66.30	920
Full stress	Farrokh	3071	13.87	56.50	710
	Ghasem	2601	13.83	62.40	544
	SHF81-90	2710	13.62	57.34	618
LSD (p≤ .05)		341.77	0.49	0.35	9.14

Head diameter

Results showed that top head diameter was formed on full irrigation condition. Under semi-stress condition, head diameter decreased 13.77% and by stress development, it reduced to 21.26% (compared to check).Soil moisture shortage at root atmosphere, had decrease effect on head diameter and therefore on Seed yield. Head diameter of SHF81-90, had increased 3.3% and 4.1% compared to Farrokh and Ghasem respectively. Zareei-Siahbidi (2005) showed that interaction between genotype and water stress was significant and head diameter under stress condition was decreased at all genotypes in comparison to check. Result showed that by super absorbent treatment, the slight but significant increase was occurred in head diameter, so by using 100kg/ha and 200kg/ha super absorbent, head diameter was increased 2.12% and 5.17 % respectively compare to control. Reaction of sunflower genotypes to water stress was more obvious than genetic variants and super absorbent application. Full irrigation treatment increased head diameter on all genotypes. This result is uniform to Nezami *et al* (2008) report.

Table 4. Interaction effects of water stress and genotype on Seed yield, head diameter, seed weight and Seed per head of new sunflower genotypes.

Treatment	Genotype	Seed yield	Head diameter	Seed weight	Seed per Head
Super absorbent (kg ha^{-1})					
0	Farrokh	4297	14.82	60.75	919
	Ghasem	4195	14.82	64.85	827
	SHF81-90	4447	15.60	64.78	883
100	Farrokh	4403	15.28	61.61	931
	Ghasem	4253	15.05	66.21	829
	SHF81-90	4528	15.89	66.03	880
200	Farrokh	4479	15.85	61.51	951
	Ghasem	4366	15.67	66.22	850
	SHF81-90	4648	16.07	65.99	908
LSD ($p \leq .05$)		31.93	0.18	0.19	14.15

Thousand Seed weight

Result showed that 1000 seed weight in full stress condition was greater than water stress. Under semi-stress and full stress conditions, thousand seed weight decreased 5.1% and 14.5% compare to control respectively. Thousand seed weight at full irrigation condition was 69 g. and at semi stress condition and full stress were 65 g. and 59 g. respectively; that uniform to Oraki *et al* (2012) report but varied to report of Erdem *et al* (2012).Also results showed that, 1000 seed weight of Ghasem and SHF81-90 (66g) in this research were greater than Farrokh (61g).

Table 5. Interaction effects of super absorbent and genotype on Seed yield, head diameter, seed weight and Seed per head of new sunflower genotypes.

Waterstress	Super absorbent (kg ha^{-1})	Seed yield	Head diameter	Seed weight	eed per Head
Full irrigation	0	5798	17.02	67.99	1116
	100	5883	17.43	69.05	1116
	200	6052	18.04	69.03	1146
Semi stress	0	4417	14.79	64.68	897
	100	4497	14.98	65.52	904
	200	4585	15.48	65.43	929
Full stress	0	2723	13.43	57.71	616
	100	2803	13.81	59.28	621
	200	2856	14.07	59.25	636
LSD ($p \leq .05$)		90.56	0.13	0.39	9.64

In fact, seed weight is affected by rate and duration of the grain filling period that supported by current photosynthesis assimilation and remobilization of stored assimilates. Soil moisture shortage during the growth period particularly at reproductive stage, reduces current photosynthesis, rate and duration of grain filling and finally seed weight. Interaction between treatments showed that the highest (73g) and lowest (57g) 1000seed weight was relative to SHF81-90. This matter showed, SHF81-90 in case of moisture, had a high seed weight and grain weight was severely reduced under drought, The highest 1000 seed weight (66g) was related to Ghasem by 200kg/ha super absorbent treatment (Tab 3). Results of current research are uniform to Alhaddadi *et al* (2012) report and results of many other researchers.

Seed per Head

Results showed that water stress reduced seed per head at semi stress (909) and full stress (624) conditions compare to control (1125). Rate of reduce in semi stress and full stress were 19.2% and 44.55% respectively. It cause because of o sterile flowers increase and small head diameter and reduce the potential of seed production due to soil moisture reduction on root atmosphere. Also results showed that the highest number of Seed per head was relative to Farrokh (933) and the lowest number of Seed per head was relative to SHF81-90 (890) and Ghasem (835). Using 100 kg/ha super absorbent did not change to number of Seed per head compare to control, but using 200 kg/ha super absorbent changed number of head grain from 876 to 903. Interaction between water stress and genotype showed that full stress increased grain number per head in all of genotypes but water stress decreased number Seed per heading all of genotypes, but at full stress was decline. The highest number Seed per head was obtained in full irrigation stress by SHF81-90(1133) and the lowest number per head (544) was obtained by Ghasem (tab 4). Gomez Sanchez *et al* (1998) concluded that water stress at vegetative stage cause a reduction in leaf area and photosynthetic rate that may lead to reduce Seed yield, and in this case, any decreases on Seed yield, resulting to significant reduction on grain weight and number.

Conclusion

Water stress was causes premature aging of leaves, reduction of photosynthesis due to stomata closure. Reduce plant growth, shortage of assimilates for grain filling and reduced grain filling period. By head diameter decrease under water stress, kernel number per head was decreased. On the other hand, seed weight also declined because of photosynthesis shortage, that leaded to yield reduction ultimately. Water stress increased remobilization of stored assimilates from stems and petioles to the main sink (seeds),but it cannot cover the current photosynthesis decrease caused by soil moisture reduction. Among genotypes, Farrokh was superior in high stress situations and SHF81-90 was superior genotype under full irrigation condition.

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