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Response of Genotypes of Sunflower to Yield and Its Genotypes under Water Stress Conditions

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Abstract

A field experiment was conducted at the experimental field of the Technical College / Al-Musayyib during the fall season of 2025 using a Randomized Complete Block Design (RCBD) with three replications. The study aimed to evaluate the performance of five genetic genotypes of sunflower (Helianthus annuus L.) under different levels of water stress and to investigate their effects on yield and its related traits. The genotypes included (Argensun, Euroflor,Selected 1, Selected 2, and the Syrian cultivar as control), while irrigation treatments consisted of three different levels of water stress. The studied traits included biological yield, 300-seed weight, number of seeds per head, seed yield per plant, and harvest index.The results showed significant differences among the genotypes, irrigation treatments, and their interaction for most of the studied traits. The Syrian cultivar outperformed the other genotypes in most yield traits, recording the highest mean values for biological yield (219.97), 300-seed weight (44.53 g), number of seeds (685.23), harvest index (46.86), and seed yield per plant (103.02 g). Irrigation treatments also had a significant effect, as the highest irrigation level (IR1) resulted in increased values for most traits compared with higher water stress levels. The results indicate the presence of genetic variation among the studied genotypes, which can be exploited in breeding programs to improve sunflower productivity and enhance its tolerance to water stress.

Keywords: *Sunflower, Water stress, Genetic compositions, Biological yield, Harvest index, Seed yield per plant.*

Introduction

Sunflower (*Helianthus annuus* L.) is considered one of the most important oilseed crops belonging to the family Asteraceae. It is cultivated mainly for its seeds, which contain a high percentage of oil ranging from 30–50%, and it is regarded as the leading oil crop in Iraq [2].The economic importance of sunflower seeds is due to the wide use of their oil, either for direct human consumption or in various industries such as soap and detergent manufacturing, as well as other industrial uses. In addition, sunflower meal is used in animal feed production. Sunflower oil is highly desirable worldwide. Reports from the Ministry of Industry indicated that the oil produced from this crop covers only about 4.06% of the total oil production in Iraq. During the autumn growing season, the national production reached about 816 Mg [4]. Sources indicate that the productivity of sunflower in Iraq does not exceed 2 Mg ha^{-1}, which is considered very low compared with the global productivity that may reach about 7.5 Mg ha^{-1} [6]. The low productivity in Iraq is attributed to several factors, including poor crop management, lack of appropriate production technologies, marketing problems, limited availability of oil extraction facilities, and inadequate storage conditions. Seed yield per plant is considered one of the important yield traits in sunflower, as it reflects the plant's ability to produce dry matter and convert it into seeds. This trait is greatly affected by water stress conditions, since water deficiency reduces the efficiency of physiological processes such as photosynthesis and nutrient uptake, which negatively affects plant growth and productivity. Studies have shown that exposing sunflower plants to different levels of water stress leads to a clear reduction in physiological indicators, resulting in a decrease in seed yield per plant [9].Several studies have reported that water stress causes a significant reduction in yield-related traits such as the number of seeds per head and seed weight, which ultimately reduces seed yield per plant compared with full irrigation treatments [10]. Other studies also indicated that water stress inhibits physiological processes in plants, including water balance and photosynthetic activity, which negatively affects flower pollination and the formation of fully

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developed seeds, resulting in a reduction in total seed yield (Abdul-Razak and Mahmood, 2014).Research findings have shown that reducing irrigation levels leads to a significant decrease in the number of seeds per head and seed weight, which in turn negatively affects total oil production[16]. Experiments also demonstrated that plants grown under water deficit conditions exhibited a reduction in seed weight ranging from 10–30% compared with plants grown under full irrigation, depending on the severity and duration of water stress [12].Furthermore, studies have shown that water stress leads to a noticeable reduction in seed weight due to decreased water and nutrient uptake, as well as its negative effect on seed growth and development during the seed filling stages[14]. This reduction is attributed to the shrinkage of seed size and the limited accumulation of nutrients within the seeds, in addition to reduced photosynthetic efficiency and carbohydrate production required for seed development [5].Studies have also indicated that water stress affects the morphological traits of the plant such as plant height, stem diameter, and leaf area, which ultimately leads to a reduction in the total biomass of the plant [13]. Moreover, water stress reduces the biological yield of sunflower due to its negative effects on the physiological and morphological processes of the plant. However, some treatments, such as the application of growth regulators or nutrients, may help alleviate drought effects and improve dry matter production in sunflower plants [11]. Other studies indicated that water stress affects yield components and oil quality in sunflower seeds. Water deficiency reduces the accumulation of dry matter in seeds compared with the vegetative parts of the plant, which leads to a decrease in the harvest index. Proper irrigation management can improve dry matter distribution within the plant and increase the efficiency of its conversion into economic yield [7]. Furthermore, studies reported that exposing sunflower plants to water stress leads to a reduction in the harvest index due to the decreased efficiency of translocation of photosynthetic products from vegetative organs to reproductive organs, which ultimately results in lower economic yield compared with biological yield [14].

Objectives of the Study

1. To evaluate the performance of five sunflower genotypes under three different irrigation levels (100%, 75%, and 50% of crop water requirements).

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2. To determine the best genotype and optimal irrigation level that achieve the highest yield under the study conditions.

3. To study the effect of the interaction between genotypes and water stress

2. Materials and Methods

2.1 Experimental Site

A field experiment was conducted at the experimental field of the Technical College / Al-Musayyib, located in Babil Province at latitude 32° N and longitude 44.30° E, during the 2025 growing season. The experiment was carried out using a Randomized Complete Block Design (RCBD) with three replications to evaluate the performance of five genetic compositions of sunflower. Seeds were sown on April 1, 2025. The experimental field was prepared by plowing, leveling, and smoothing the soil. The land was then divided into experimental units. Each experimental unit consisted of four rows, with each genotype planted in four rows of 4 m length, with 75 cm spacing between rows and 25 cm between hills, resulting in 64 plants per experimental unit and a plant density of 53,333 plants per hectare [3].Nitrogen fertilizer was applied in the form of urea (46% N) at a rate of 160 kg N ha^{-1}, divided into two applications: the first at planting and the second at the flowering stage. Triple superphosphate fertilizer (46% P_2O_5) was applied as a single dose at a rate of 80 kg P_2O_5 ha^{-1} before planting [8].All agronomic practices were carried out according to the recommended agricultural practices, and irrigation treatments were applied at three levels: 100%, 75%, and 50% of the crop water requirement.

2.2 Soil Sampling and Analysis

Prior to planting, five soil samples were randomly collected from the experimental field at a depth of 0–30 cm. The collected samples were cleared of debris, thoroughly mixed to obtain a composite sample, air-dried, and homogenized. A representative subsample was then subjected to laboratory analysis to determine selected physical and chemical soil properties, following the procedures described by [17].

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The soil analyses were conducted in the Soil Laboratory of Al-Musayyib Technical Institute.

Table 1. Selected physical and chemical properties of the experimental soil

Unit of Measurement	Quantity	Attribute
--------	**7.8**	**Soil reactivity level (PH)**
Ds.m-1	4.5	**Electrical conductivity (CE)**
mg.kg-1	1.6	**Total nitrogen**
mg.kg-1	5.10	**Ready-made phosphorus**
mg.kg-1	4.7	**Ready-made potassium**
gm.kg-1	15.57	**organic matter**
g.kg-1	480	**sand**
g.kg-1	325	**silt**
g.kg-1	195	**clay**
	Alluvial mixture	**weave**

2.3 Yield characteristics and components

Five plants were randomly selected from each experimental unit to evaluate the following traits:

Number of seeds per head:

It was determined using a seed counter device in the Physiology Laboratory at Al-Musayyib Technical College.

300-seed weight (g):

The weight of seeds was measured using a sensitive (analytical) balance.

Biological yield (Mg ha^{-1}):

The total weight of leaves, stems, and heads was recorded and then converted to megagrams per hectare (Mg ha^{-1}).

Total seed yield (g):

The yield per unit area was obtained by harvesting plants from the three central rows after excluding one meter from each end. Accordingly, the experimental unit area was $3 \times 3 = 9\ m^2$.

Harvest index (%):It was calculated using the following equation:

$$HI = \frac{Economic Yield}{Biological Yield} \times 100$$

Statistical Analysis

The data were statistically analyzed for the factorial experiment according to the design of completely randomized blocks using the (GenStat) program and using the Least Significant Difference (LSD) test to compare means at a probability degree of (0.05) GenStat (2017).

4.Results and Discussion

Number of Seeds

Table (2) show highly significant differences among water stress treatments, genotypes, and their interaction. The lowest mean number of seeds was 461.56 seeds at 50% of the water requirement. This decrease may be attributed to the reduction in irrigation levels, which leads to a significant decrease in the number of seeds per head, negatively affecting total oil production. On the other hand, the highest mean number of seeds reached 739.88 seeds at 75% of the water requirement. These results agree with [16] [1]. Significant differences were observed among the genotypes. The genotype (S2) recorded the lowest mean of 541.00 seeds, whereas (V3) recorded the highest mean of 685.23 seeds. This may be attributed to genetic factors related to the genotype itself as well as differences in their response to environmental conditions. The genotype (V2) also showed relatively high seed number values. A highly significant interaction was observed between water stress treatments and genotypes. The interaction (S1 × IR3) recorded the lowest number of seeds (373.60 seeds), while the interaction (V3 × IR2) recorded the highest number of seeds (803.10 seeds) compared with (V2 × IR2) which recorded 788.90 seeds.

Table (2). Effect of Water Stress, Genotypes, and Their Interaction on Number of Seeds

Genotypes	Irrigation Treatments			Mean of Genotypes
	IR1	IR2	IR3	
(V1) Argensun (Parent1)	575.20	745.10	430.80	583.70
(V2) Euroflor (Parent2)	725.10	788.90	492.40	668.80
(S1) (Selected1)	659.90	724.70	373.60	586.07
(S2) (Selected2)	534.80	637.60	450.60	541.00
(V3) Syrian (Check)	692.20	803.10	560.40	685.23
lsd5%	47.53**			27.44**
Mean of Irrigation Treatments	637.44	739.88	461.56	
lsd5%				

300-seed weight

Table (3) indicate highly significant differences among water stress treatments, genotypes, and their interaction. The lowest mean 300-seed weight was 34.26 g under 50% of

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the water requirement, and this decrease may be attributed to the reduction in seed size and the limited accumulation of nutrients within the seeds, in addition to the reduction in photosynthetic efficiency and carbohydrate production necessary for seed filling. In contrast, the highest mean 300-seed weight was 43.56 g at 75% of the water requirement. These results are consistent with the findings reported by [12]. Significant differences were also observed among the genotypes. The genotype (V1) recorded the lowest mean of 37.40 g, whereas (V3) recorded the highest mean of 44.53 g. This difference may be attributed to genetic factors related to the genotype itself, as well as variations in their response to environmental conditions. The genotype (S2) recorded a relatively higher mean value of 39.57 g compared with the other studied genotypes. The same table also showed a significant interaction between water stress treatments and genotypes. The interaction (V1 × IR3) recorded the lowest 300-seed weight of 29.70 g, while the interaction (V3 × IR2) produced the highest 300-seed weight of 43.56 g, compared with (V2 × IR2) which recorded a high 300-seed weight of 42.10 g.

Table (3) shows the effect of water stress, Genotypes, and their interaction on the 300-seed weight.

Genotypes	Irrigation Treatments			Mean of Genotypes
	IR1	IR2	IR3	
(V1) Argensun (Parent1)	42.00	40.50	29.70	37.40
(V2) Euroflor(Parent2)	38.80	42.10	32.50	37.80
(S1) (Selected1)	37.90	42.00	34.80	38.23
(S2) (Selected2)	41.40	43.60	33.70	39.57
(V3) Syrian (Check)	43.40	49.60	40.60	44.53
lsd5%	3.64*			2.10**
Mean of Irrigation Treatments	40.70	43.56	34.26	
lsd5%	2.63**			

Biological Yield

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Table (4) indicate highly significant differences among water stress treatments, genotypes, and their interaction. The lowest mean biological yield was 213.80 g plant^{-1} at 100% of the water requirement. This may be attributed to water deficiency, which reduces biological yield due to the decrease in leaf area, reduced photosynthetic rate, and limited accumulation of dry matter in both vegetative and reproductive parts of the plant. In contrast, the highest mean biological yield reached 233.28 g plant^{-1} at 75% of the water requirement. These results do not agree with those reported by [13][11]. Significant differences were observed among the genotypes. The genotype (S1) recorded the lowest mean biological yield (174.57 g plant^{-1}) compared with (V3) which recorded the highest mean 219.97 g plant^{-1}. This difference may be attributed to genotypes of the genotype itself as well as differences in their response to environmental conditions. The genotype (V2) also recorded a relatively high mean 201.37 g plant^{-1}.Asignificant interaction between water stress treatments and genotypes was also observed. The interaction (S1 × IR3) recorded the lowest biological yield (109.30 g plant^{-1}), whereas the interaction (V3 × IR2) recorded the highest biological yield (257.30 g plant^{-1}) compared with (V2 × IR2) which recorded 250.70 g plant^{-1}.

Table (3). Effect of Water Stress, Genotypes, and Their Interaction on Biological Yield (g plant^{-1})

Genotypes	Irrigation Treatments			Mean of Genotypes
	IR1	IR2	IR3	
(V1) Argensun (Parent1)	206.00	210.70	124.00	180.23
(V2) Euroflor (Parent2)	231.70	250.70	121.70	201.37
(S1) (Selected1)	189.70	224.70	109.30	174.57
(S2) (Selected2)	196.30	223.00	118.30	179.20
(V3) Syrian (Check)	245.30	257.30	157.30	219.97
lsd5%	17.79*			10.27**
Mean of Irrigation Treatments	213.80	233.28	126.12	
lsd5%	13.67**			

Seed Yield

Table (5) showed highly significant differences among water stress treatments, genotypes, and their interaction. The lowest mean seed yield per plant was 55.01 g at 50% of the water requirement. This reduction may be attributed to water stress, which significantly reduces yield-related traits such as the number of seeds per head and seed weight, leading to a decrease in seed yield per plant compared with full irrigation treatments. On the other hand, the highest mean seed yield per plant was 107.76 g at 75% of the water requirement. These results agree with the findings of [10][9]. Significant differences were observed among the genotypes. The genotype (S2) recorded the lowest mean 72.53 g, whereas (V3) recorded the highest mean 103.02 g. This difference may be attributed to genetic characteristics of the genotype as well as differences in their response to environmental conditions. The genotype (V2) also recorded a relatively high mean 84.15 g. A highly significant interaction between water stress treatments and genotypes was observed. The interaction (S1 × IR3) recorded the lowest seed yield per plant (43.36 g), whereas the interaction (V3 × IR2) recorded the highest seed yield per plant (133.78 g) compared with (V2 × IR2) which recorded 109.88 g.

Table (5). Effect of Water Stress, Genotypes, and Their Interaction on Seed Yield per Plant (g)

Genotypes	Irrigation Treatments			Mean of Genotypes
	IR1	IR2	IR3	
(V1) Argensun (Parent1)	81.01	100.62	51.61	77.75
(V2) Euroflor (Parent2)	89.29	109.88	53.27	84.15
(S1) (Selected1)	83.52	101.95	43.36	76.28
(S2) (Selected2)	74.03	92.59	50.96	72.53
(V3) Syrian (Check)	99.42	133.78	75.86	103.02
lsd5%	6.03**			3.48**
Mean of Irrigation Treatments	85.45	107.76	55.01	
lsd5%	2.07**			

Harvest Index

Table (6) indicate highly significant differences among water stress treatments, genotypes, and their interaction. The lowest mean harvest index was 40.05% at 50% of the water requirement. This reduction may be attributed to water stress, which decreases the harvest index due to reduced efficiency of translocation of photosynthetic products from vegetative parts to reproductive organs, leading to a lower economic yield compared with the biological yield. In contrast, the highest mean harvest index was 46.09% at 75% of the water requirement. These results are consistent with the findings of [7] [15]. Significant differences were also observed among the genotypes. The genotype (V1) recorded the lowest mean harvest index (40.42%), whereas (V3) recorded the highest mean 46.86%. This variation may be attributed to genetic differences among the genotypes as well as their different responses to environmental conditions. The genotype (S1) also recorded a relatively high mean value of 43.12%. A highly significant interaction between water stress treatments and genotypes was observed. The interaction (V1 × IR3) recorded the lowest harvest index (34.43%), whereas the interaction (V3 × IR2) recorded the highest harvest index (51.79%), compared with (S1 × IR2) which recorded 45.31%.

Table (6). Effect of Water Stress, Genotypes, and Their Interaction on Harvest Index (%)

Genotypes	Irrigation Treatments			Mean of Genotypes
	IR1	IR2	IR3	
(V1) Argensun (Parent1)	39.33	47.49	34.43	40.42
(V2) Euroflor(Parent2)	38.54	43.71	43.73	41.99
(S1) (Selected1)	44.08	45.31	39.96	43.12
(S2) (Selected2)	37.74	42.14	42.55	40.81
(V3) Syrian (Check)	40.54	51.79	48.26	46.86
lsd5%	2.80**			1.62**
Mean of Irrigation Treatments	40.05	46.09	41.79	
lsd5%	1.80**			

Conclusion

The results indicate that water stress had a significant effect on seed weight. A reduction in irrigation level led to a decrease in the weight of 300 seeds due to reduced photosynthetic efficiency and poor nutrient accumulation in the seeds. The genotypes also showed differences in their response to irrigation treatments, with the Syrian variety (V3) outperforming the other genotypes for this trait. Additionally, the interaction between irrigation treatments and genotypes was significant, as the combination of the Syrian variety with medium irrigation produced the highest seed weight, indicating the efficiency of this genotype in utilizing available water conditions.

The results show that reduced irrigation levels decreased the number of seeds per flower head due to the negative impact on pollination and fertilization processes and reduced photosynthetic efficiency under water stress conditions. Significant differences among genotypes were also observed, with the Syrian variety (V3) recording the highest number of seeds compared to the other genotypes. Furthermore, a significant interaction between irrigation and genotypes was detected, where the Syrian variety under medium irrigation produced the highest number of seeds.

The results demonstrate that biological yield is significantly affected by different irrigation levels. Reduced water supply decreased dry matter accumulation in the plants due to reduced leaf area and lower photosynthetic rates. Differences among genetic genotypes were observed in their ability to produce biomass, with the Syrian variety (V3) outperforming the other genotypes in biological yield. A significant interaction between irrigation levels and genotypes was also evident, indicating that genotypes respond differently to water stress conditions.

The results indicated that water stress reduces the harvest index due to inefficient translocation of photosynthetic products from vegetative parts to reproductive organs. Significant differences among genotypes were observed, with the Syrian variety (V3) achieving the highest harvest index compared to other genotypes. Additionally, a significant interaction between irrigation treatments and genotypes was detected, indicating that the response of this trait depends on both the genotype and water availability.

The results show that water stress reduced seed yield per plant due to its negative effect on yield-related traits such as the number of seeds and seed weight. Significant differences among genotypes were observed, with the Syrian variety (V3) producing the highest seed yield per plant compared to other genotypes. The interaction between irrigation treatments and genotypes was significant, with the Syrian variety under medium irrigation producing the highest plant yield.

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