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Effect Of Gibberellic Acid And Water Stress In Growth, Yield Characteristics And Oil Percentage On Sunflower

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Abstract

A field experiment was conducted during spring season 2021 at the Agricultural Research Station, College of Agriculture, University of Basrah (Al-Haritha site) at 25 km from the center of Basrah Government, to determine the effect of four concentration of Gibberellic acid (G_0=0, G_1=100, G_2=200, G_3=300 ppm) and three levels of water stress (S_1=%100, S_2= %75, S_3=%50 from field capacity) on the growth, yield and oil quality of sunflower (Helianthus annuus L.), Aqmar cultivar. The experiment was carried out by a Split- Plot according to Randomized Complete Block Design (R.C.B.D.) with tow replicates. Water stress levels occupied the main- plot, and Gibberellic acid concentration occupied sub-plot. The results showed that (G_1) was significantly superior in leaf area, disc diameter, plant yield, biology yield, harvest index and oil yield. The water stress (S_1) was significantly superior in all studied traits. The interaction between Gibberellic acid and water stress showed the superiority, the combination (S_1 G_1) give the best mean in all studied traits comported with (S_3 G_0) which gave lowest of means.

Keywords: Gibberellic acid, growth, yield, oil quality, Sunflower (Helianthus annuus L.), water stress.

Introduction

The sunflower (Helianthus annuus L.), one of the important industrial crops, belongs to compositae family, the third ranks after soybeans and rapeseed in the amount of oil production worldwide, it grows widely in many parts of the world, because of the drought-tolerant and water-efficient crops (Bajehbaj, 2010).

The sunflower crop is characterized by a high percentage of oil in the seeds, up to 55% in some items, the oil contains a high percentage of unsaturated fatty acids, such as oleic and linoleic up to 25.1-66.2%. Sunflower oil is also rich in protein, contains 30-35% protein, sunflower oil is used for nutrition, in the manufacture of soap, dyes, cosmetics, and in various food industries, to ensure the growth and yield of plants in unsuitable conditions. Growth regulators were used as stimulating materials to increase yield and help or reduce the impact of various environmental stresses, especially water stress there were a number of recent studies focused on improving, or reduce the harmful effects of water stress on plants, through spraying with nutrients and growth regulators, including gibberellic acid, an important role in increasing the growth and yield of plants exposed to water stress, it was used in low concentrations, makes the plant to exploit its inherent physiological and genetic capabilities, by increasing the absorption of water and nutrients with high efficiency, gibberellins are organic compounds, which plants need in low concentrations to perform certain roles. Some studies indicated that spraying with some growth regulators, such as gibberellic acid has contributed to increasing the plant's tolerance to water stress conditions, by stimulating vegetative growth, by increasing cell division and thus increasing yield and productivity (Jan et al., 2019).

Gibberellic acid is one of the most important plant hormones, leads to an increase in the speed of germination (Kirecci, 2018). Gibberellic helps stimulate the necessary hydrolytic enzymes, for the breakdown of nutrients and cell division, such as alpha-amylase and beta-amylase, a number of enzymes, the most important of which are protease and rib nuclease (Attiya and Jaddoa, 1999).

Water stress is defined as the absence of water necessary for the life of a plant for a certain period of time, it limits plant growth processes (Elsahookie et al., 2009). The vegetative stage is an active stage of cell growth, expansion and division, affected by water stress, leads to inhibition of cell growth and division, the plant height decreases (Yaqoub et al., 2010).

Water stress leads to a decrease in the number and area of leaves, leads to a decrease in the level of photosynthesis and its products, decreased plant production of dry matter (Afkari, 2010). Water stress is one of the most important abiotic challenges, that interfere with the growth and productivity of plants, causes a defect in its growth. Nezami et al. (2008) indicated a decrease in plant height in sunflower yield under water stress conditions. Oraki et al. (2012) showed a significant increase in the content of proline and total sugars and a decrease in the chlorophyll content of leaves at water stress. The efficiency of water use led to an increase in production per unit area (Boko et al., 2018).

The current study aims to determine the effect of gibberellic acid on the growth, yield and quality of sunflower oil under water stress.

Materials Methods

The field experiment was carried out at Al-Hartha Research Station, University of Basrah, 25 km north of the center of Basra Governorate, during the spring season 2021, at silty loam soils, to study the effect of gibberellic acid on the growth, yield and quality of sunflower oil under water stress. Aqmar cultivar was used, the cultivar approved by the Ministry of Agriculture. The experiment was carried out by a Split- Plot according to Randomized Complete Block Design (R.C.B.D.) with tow replicates. As the water stress levels occupied the main panels, three levels (50, 75 and 100%) of field capacity, it was given the symbols (S1, S2, and S3). The concentrations of gibberellic acid occupied the sub plots in four concentrations (0,100, 200 and 300ppm), it was given (G0, G1, G2 andG3). It was 24 experimental units. The ground, after being prepared, was divided according to the adopted design, the area of each experimental unit (3 × 3 m), it contains four furrows (3 m) long, the distance between the furrow is 75 cm and the furrow was 25 cm. Use nitrogen fertilizer (urea N 46%) 320 kg ha^{-1} in two batches, the first is at planting and the second is a month after the first batch and triple superphosphate fertilizer (P_2O_5 47 %) at a rate of 100 kg ha^{-1} before planting (Al-Abedy, 2011). 3-4 seeds were placed in the hole, then reduced to one plant in the hole, weeding control was performed as needed, irrigation using flexible plastic tubes with a meter, to calculate the amount of water added to the water stress levels, which were 100, 150 and 200 liters, respectively. Volumetric methods was used to measure soil moisture (Zein, 2002).

The volumetric moisture content was estimated according to the following treatment: QV1 = QW x Pb, since- :

QV1 = moisture content based on volume.
QW = moisture content based on weight.
Pb = bulk density of soil (Mg. m^3).
The quantities of irrigation water for a depth of 30 cm for the irrigation treatments (S1, S2 andS3) were 1(200,150,100) liters / 9 m^2, respectively. The amount of added water was calculated according to the following equation:

$$\mathbf{W = A \times Pb(\frac{\%PWF.C - \%PWW}{100}) \times \frac{D}{100}}$$

as that

W = volume of water to be added during irrigation
A (m^3) = area of the experimental unit
Pb (m^2) = bulk density of soil (mg. m^3).
PWF.C = Percentage of soil moisture based on weight at field capacity (after irrigation).
PWW = percentage of soil moisture (before watering).
D = soil depth (m).

The different treatments were sprayed in two stages, the first 45 days after planting, the stage of the appearance of the flower disc (the stage of completion of vegetative growth). The second after a month from the first spray when the first disc flower was formed (the stage of flower formation, the spraying took place early in the morning, using a 20 liter backpack sprayer, the comparison treatment was sprayed with distilled water only.

Table (1): Some chemical and physical properties of the experimental soil before planting.

Character texture	**pH**	**E.C**	**N**	**P**	**K**	**Clay**	**Silt**	**Sand**	**Soil**
Volume	7.00	29.00	37.00	12.75	0.36	340	590	70.00	Silty clay loam
Unit		dsm^{-1}	mg kg-1 Soil						

Traits studied

Leaf area (cm^2): The leaf area was measured by the following equation:

Maximum leaf width × sum of squares of leafs × 0.65.

Disc Diameter (cm): It was calculated by the part that includes the flower discs.

The individual plant yield (g plant^{-1}): It was calculated from the average yield of one plant after the flowering disc of the ten plants randomly selected from the two middle lines, their seeds separated, and the weight of each plant separately.

Biological yield (kg ha^{-1}): It was calculated through the weight of all parts of the plant that lie above the soil surface, including leaves, stems and discs, in addition to the weight of the seeds.

Harvest Index (%): It was calculated by dividing the economic yield (total seed yield) by the biological yield multiplied by 100.

Total oil yield (kg ha^{-1}): It was calculated from the following equation: - Percentage of oil x total seed yield (kg ha^{-1}).

Results and discussion

Leaf area (cm^2):

Table (2) indicates that there were significant differences for the effect of gibberellic acid concentrations and water stress and the interaction between them. The concentration of gibberellic acid (G1) gave the highest mean for the leaf area characteristic of 5206.2 cm^2, compared with the concentration of gibberellic acid (G0) no gibberellic acid was added, which gave the lowest average for this trait amounted to 3325.0 cm^2 and a percentage of more than 11%, while the two concentrations of gibberellic acid (G2 and G3) were averaged 4946.8 and 4340.6 cm^2 respectively, this may be due to the low concentrations of gibberellic acid, it plays an important role in preparing many physiological responses in plants, helps to accelerate the growth of the vegetative part by increasing the elongation and number of cells, contributes to increasing the number of papers and their paper area (Bibi et al., 2003).

As for the effect of water stress, the table also indicates the superiority of treatment (S1) by giving the highest mean of the leaf area characteristic of 5228.9 cm^2, compared with treatment (S3), which gave the lowest mean for this trait, which was 3318.7 cm^2, while treatment (S2) gave an average of 4816.4 cm^2. The reason for the reduction in the area of leaves by reducing the amount of irrigation may be due to the decrease in the number of leaves, as well as reducing the relative water content in the leaves, which led to a decrease in the water potential of the leaves, causing a reduction in the size of cells and their ability to elongate and widen, this result agrees with Bajehbaj (2010), who showed that the decrease in the water potential of the leaves and their relative water content, it may reduce their ability to elongate and bulge and thus reduce leaf area, these results were in agreement with (Elnaim and Ahmed, 2010; Mojaddam et al., 2011; Ebrahimian and Bybordi, 2011).

As for the effect of the interaction between the concentrations of gibberellic acid and the levels of water stress, the same table indicates that the combination between the concentration of gibberellic acid and the water stress (S1 G1) gave the highest average leaf area characteristic of 6084.3 cm^2, compared with the combination (S3 G0), which gave the lowest average for this trait, which was 2625.0 cm^2. The reason for this is that the low concentration of gibberellic acid prepare many physiological responses, increases the efficiency of the photosynthesis process in plants, accelerate the growth of the vegetative part in conjunction with the availability of sufficient water, led to an increase in the water potential inside the leaves, causing an increase in the leaf area (Kirecci, 2018).

Disc diameter (cm):

Table (2) indicates that there were significant differences for the effect of adding concentrations of gibberellic acid and water stress and the interaction between them on the disc diameter of the sunflower crop. The concentration of gibberellic acid (G1) gave the highest mean for the characteristic of the disc diameter was 17.62 cm, compared with not adding gibberellic acid (G0), which gave the lowest average for this trait, which was 14.70 cm, whereas, the two treatments (G2 and G3) gave averages of 16.78 and 15.25 cm, respectively.

The results indicate that the water stress level (S1) gave the highest mean for the characteristic of the disc diameter, did not differ significantly from the water stress level (S2), which were given averages of 16.94 and 16.66 cm, respectively, compared with the water stress level (S3), which gave the lowest average for this characteristic, it was 14.67 cm. The increase in the diameter of the disc may be due to the availability of suitable moisture with a balanced concentration of gibberellic acid, led to the readiness of nutrients in the soil, increasing the efficiency of its transport and ease of absorption by root cells, reflected in the increase in the number of leaves, leaf area, index and chlorophyll content in leaves, increase the efficiency of the photosynthesis process, dry matter production which was positively reflected in the formation of larger tablets, agrees with Cecconi et al. (2002); Al-Jobori (2012). The increase in disk diameter was 15.47%, perhaps the reason for this superiority was that when the water stress increases, the diameter of the disk decreases, as a result of the lack of material access to the disk, due to the decline of photosynthesis and the decrease of leaf area and guide, water stress leads to an impediment of vital reactions, an important role in the formation of tissues, which is reflected in the decrease in the size of the disc and the number of seeds in it, this result was in agreement with Kheybari (2013); Kantar et al. (2014); Hussain et al. (2014), who noticed a decrease in the disc diameter by the effect of water stress.

As for the effect of interaction, the concentration of gibberellic acid (G1) at the water stress level (S1), the highest mean of disc diameter was given, as the treatment (S1 G1) gave an average of 18.24 cm, compared with not adding gibberellic acid at the water stress level (S3), as the treatment (S3 G0) gave the lowest average for this trait, which was 12.40 cm.

Individual plant yield (g plant^{-1}):

A significant differences in the effect of gibberellic acid concentrations and water stress levels and the interaction between them on the trait of individual plant yield. The low concentration of gibberellic acid (G1) gave the highest mean for the yield of the individual plant, which was 65.29 g plant^{-1}, compared with not adding gibberellic acid (G0), which gave the lowest average for this trait, which was 37.73 g plant^{-1}, while the concentrations (G2 and G3) gave averages of 59.49 and 42.50 g plant^{-1}, respectively. The reason for this may be due to the low concentration of gibberellic acid, it delayed aging, which was reflected in the increase in the number and weight of seeds, led to an increase in the individual yield per plant, this was in agreement with Bibi et al. (2003); Naghashzadeh et al. (2009); Jerusha et al. (2021).

The water stress level (S1) gave the highest mean for the yield of the individual plant, which was 59.84 g plant^{-1}, compared with the water stress level (S3), which gave the lowest average for this trait was 41.82 g plant^{-1}, while the water stress level (S2) gave an average of 52.10 g plant^{-1}. The decrease in the yield of the individual plant at the level (S3) may be due to the effect on the growth rate and the development of the crop, because of the small size of the disc, the low number of seeds in the disc and the weight of a thousand grains, which negatively affected the seed yield per plant, which led to its decline these results were in agreement with Iraj et al. (2011); Hassan (2014), they indicated that water stress reduces seed yield as a result of its effect on disc size, number of seeds in the disc and seed weight. It may be attributed to the fact that the diameter of the stem plays an important role in increasing the yield of the plant, by increasing the vascular bundles of nutrients, because of the increase in the layers of bark and wood, as well as the pulp, leads to the formation of a balanced and large vegetative and root system, which is reflected in the increase in growth and seed yield.

As for the effect of the interaction, the above table showed that the combination (S1 G1) gave the highest average yield of an individual plant, which was 73.99 g plant^{-1}, compared with not adding gibberellic acid at the water stress level (S3), the combination (S3 G0), which gave the lowest mean for this trait, was 32.49 g plant^{-1}.

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

Table (2) indicates that there were significant differences between the concentrations of gibberellic acid and water stress, and the interaction between them on the biological yield of sunflower crop, the low concentration of gibberellic acid (G1) gave the highest mean of the bio-crop characteristic of 10346 kg ha^{-1}, compared with not adding gibberellic acid (G0), which gave the lowest average for this trait, which was 6802 kg ha^{-1}, while the rest of the concentrations (G2 and G3) gave averages of 9604 and 7210 kg ha^{-1}, respectively. The reason for the superiority of the treatment of the concentration of gibberellic acid (G1) may be attributed to the effect of the low concentration of gibberellic acid, increasing growth, the number of cells and their elongation, increasing cell division, and thus increasing the vegetative sum of leaves and stems, which causes the efficiency of photosynthesis products, thus, increasing the total seed yield, reflected in the high rate of biological yield of the plant, agreed with Jafri et al. (2015); Jerusha et al. (2021).

The water stress level (S1), which gave the highest mean for the characteristic of the biological yield, was 9268 kg ha^{-1}, did not differ significantly from the water stress level (S2), which gave an average of 8788 kg ha^{-1}, compared with the water stress level (S3), which gave the lowest average for this characteristic, it was 7416 kg ha^{-1}, there is no significant difference between (S1) and (S2) levels. Increases water use efficiency and allows saving 25% of water, it may be used to irrigate other plants, especially with a scarcity of irrigation water, may be due to a decrease in the biological yield, with the increase of the water stress to its effect on the number of leaves, their leaf area and the height of the plant, respectively, the rate of photosynthesis decreased, which was reflected on the vegetative system (leaves and stems) and seed yield, thus, the biological yield is reduced, the result was in agreement with Kazemeini et al. (2009); Babaeian et al. (2011).

As for the effect of interaction, (S2 G1), as it gave the highest average for the characteristic of the biological yield, which amounted to 11410 kg ha^{-1}, compared with treatment (S3 G0), which gave the lowest mean for this trait, which was 6021 kg ha^{-1}.

Harvest Index Adjective (%):

Table (2) indicates that there were significant differences between the concentrations of gibberellic acid and water stress and the interaction between them in the trait of harvest index for sunflower crop. The low concentration of gibberellic acid (G1) gave the highest mean of the harvest index trait, which amounted to 33.54%, compared with not adding gibberellic acid (G0), which gave the lowest average for this characteristic of 29.48%, as the concentration of gibberellic acid (G1) gave an increase of 13.77%, while the concentrations (G2 and G3) gave averages of 32.88 and 31.25%, respectively. The superiority of the low concentration of gibberellic acid (G1) may be attributed to the characteristic of harvest index, to the effect of gibberellic acid in increasing the efficiency of photosynthesis by increasing the number of leaves and their leaf area, thus, the increase in the weight of the seeds and the ease of movement of the dry matter from the source (leaves) to the downstream (seeds), which was reflected in increasing the economic yield of plants and then increasing the harvest index, agreed with Jafri et al. (2015); Jerusha et al. (2021).

The water stress level (S1), which gave the highest mean for the harvest index trait, was 34.17%, compared with the water stress level (S3), which gave the lowest average for this characteristic, it was 29.94%. The water stress level (S1) gave an increase of 14.12%, while the water stress level (S2) gave an average of 31.25%, perhaps the reason for the low harvest evidence of plants exposed to water stress in the flowering stage, to lower the products of photosynthesis, thus, the weight of the manufactured dry matter is reduced, which caused a reduction in the seed yield of plants and then a decrease in the harvest index, as for plants exposed to water stress S1 (100% of field capacity), it gave the highest harvest evidence. The reason for this may be due to the increase in the efficiency of the transfer of elements and nutrients, to the presence of sufficient moisture and then increase the dry matter, reflected in the increase in seed weight and thus increase in harvest index, agrees with Alahdadi et al. (2011); Dehkhoda et al. (2013).

As for the effect of the interaction, the treatment of (S1 G1) was superior to the interaction, which gave the highest average for the characteristic of the harvest index, which amounted to 37.14%, compared with treatment (S3 G0), which gave the lowest average for this trait, which was 28.78%.

Total oil yield (kg ha^{-1}):

Table (2) indicates that there were significant differences in the concentrations of gibberellic acid and levels of water stress, and the interaction between them in the characteristic of the total oil yield of the sunflower crop. The results showed the superiority of the concentration of gibberellic acid (G1), which gave the highest average for the characteristic of the total oil yield, which amounted to 1361.5 kg ha^{-1}, compared with not adding gibberellic acid (G0), which gave the lowest average for this trait, which was 701.7 kg ha^{-1}, while the

concentrations (G2 and G3) gave averages of 1207.8 and 820.8 kg ha^{-1}, respectively. The reason for the superiority of the concentration of low gibberellic acid G1 (100 ppm) may be attributed to the characteristic of the total oil yield, to the superiority of this concentration in the percentage of oil, as well as giving it the highest average in the total seed yield, because of the effect of gibberellic acid in low concentrations, a positive effect on the downstream efficiency of the seeds, absorption of the products of photosynthesis, helped to increase the weight and the total seed yield and increase the proportion of oil in the seeds, agrees with Jafri et al. (2015).

As for the effect of water stress, Table (2) indicates the superiority of the water stress level (S1), as it gave the highest average for the characteristic of the total oil yield, which amounted to 1269.0 kg ha^{-1}, compared with the water stress level (S3), which gave the lowest average for this characteristic, it was 759.1 kg ha^{-1}, while the water stress level (S2) gave an average of 1040.8 kg ha^{-1}, perhaps the reason for this is that full irrigation without water stress (100% of the field capacity), it gave the highest average total oil yield due to the availability of sufficient water in the cells, helped to increase the inflated pressure of cells and stimulated growth and elongation, increasing the vegetative total, reflected in an increase in the efficiency of the photosynthesis process, resulting in an increase of nutrients inside the seeds, reflected in the increase in the oil yield in the seeds, this result was in agreement with Hussain et al. (2008); Kazemeini et al. (2009).

As for the effect of interaction, the above table indicates the superiority of the interference treatment (S1 G1), as it gave the highest average total oil yield of 1655.7 kg ha^{-1}, compared with the interaction treatment (S3 G0), which gave the lowest mean for this trait was 537.7 kg ha^{-1}.

Table (2): Effect of gibberellic acid concentrations and water stress levels and the interaction between them on some growth, yield and quality characteristics of sunflower crop.

Treatment	L.A. (cm^2)	Dim. (cm)	PY. (gm p^{-1})	BY. (kg h^{-1})	HIN. (%)	TO. (kg h^{-1})
S_1	5228.90	16.94	59.84	9268	34.17	1269.0
S_2	4816.40	16.66	52.10	8788	31.25	1040.8
S_3	3318.74	14.67	41.82	7416	29.94	759.1
G_0	3325.00	14.70	37.73	6802	29.48	701.7
G_1	5206.24	17.62	65.29	10346	33.54	1361.5
G_2	4946.87	16.78	59.49	9604	32.88	1207.8
G_3	4340.62	15.25	42.50	7210	31.25	820.8
S_1 * G_0	3768.75	15.78	45.00	7787	30.82	898.5
S_1 * G_1	6084.37	18.24	73.99	10638	37.14	1655.7
S_1 * G_2	5906.25	17.43	68.38	10412	35.06	1466.0
S_1* G_3	5156.25	16.31	51.97	8235	33.66	1055.7
S_2 * G_0	3581.25	15.93	35.69	6598	28.84	669.0
S_2 * G_1	5671.87	17.74	70.13	11410	32.78	1454.3
S_2 * G_2	5456.25	17.03	62.83	10201	32.84	1267.9
S_2 * G_3	4556.25	15.95	39.74	6942	30.54	771.9
S_3 * G_0	2625.00	12.40	32.49	6021	28.78	537.7
S_3 * G_1	3862.50	16.88	51.74	8989	30.70	974.5
S_3 * G_2	3478.12	15.90	47.26	8199	30.75	889.5
S_3 * G_3	3309.37	13.50	35.78	6454	29.56	634.8

S=water stress levels**, G=**gibberellic acid concentrations, **L.A=** leaf area, **Dim=** diameter, **PY=** plant yield**, BY=** biology yield**, HIN=** harvest index, **TO=** total oil yield**.**

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