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Effect of Humic acid on the growth, yield components, and yield of three sunflower cultivars (*Helianthus annuus* L.)

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ABSTRACT

A field experiment was carried out during the Spring 2020 season at Al-Huwair area, north of Basra Governorate, to evaluate the effect of sprinkling three levels of humic acid (0, 3, 6 and 9 ml l^{-1}) on the growth and yield of three sunflower cultivars; namely Zahrat al Iraq, Aqmar, and Flamme. The Aqmar cultivars provided the highest mean of plant height, stem diameter, leaf area, head diameter, number of seeds per head, 1000 seed weight, seed yield, and percentage of oil. The point of humic acid (9) mL/L^{-1} gave the highest mean of plant height, stem diameter, leafy area, head diameter, number of seeds per head, weight of 1000 seeds, yield of seeds, and percentage of oil. The effect of the cultivar interaction and humic acid concentration levels was important. The Aqmar cultivar recorded the highest mean of plant height, stem diameter, leaf area, head diameter, number of seeds per head, weight of 1000 seeds, seed yield, and percentage of oil at (9) mL/L^{-1} concentration level.

Key words : *Cultivars, Humic acid, Oil percentage, Seed yield, Sunflower, Yield components.*

Introduction

Sunflower crop, *Helianthus annuus* L., is an important oil crop; it belongs to the Compositae family. Its oil content is 49-39%, and it is one of the health oils because it contains Omega-3 fatty acid, Vitamin C and B, in addition to unsaturated fatty acids (Nasralla *et al*., 2014). Its seeds are used in the production of edible oil, as well as its uses in various industrial fields such as the manufacture of dyes and soaps. As for the meal, it contains 30-35% protein, as it is used for feeding poultry and livestock (Safar, 1995). Also, 64 g of dry sunflower seeds provide 370 calories; its' seeds are rich in minerals such as calcium, copper, iron, magnesium, and phosphorus (Nandha *et al.,* 2014). Cultivars have played a significant role in increasing the production of many crops, including the sunflower crop, as the genetic structures differ in their response depending on the genetic susceptibility of each genetic composition in converting the manufactured food from the source to the sink, so the choice of the genotype with high productivity represents the other direction after serving the soil and crop plants to reach the best possible production (Al-Hilali, 2005). In spite of the efficiency of chemical fertilizers in increasing production and improving quality, it has a harmful effect on human health, which requires reducing chemical fertilizers and adding organic compounds that are not harmful to the environment and

human health, increasing the plant's resistance to harsh environmental conditions (Shehata *et al.,* 2011; AL-Taey and AL-Musawi, 2019). Organic fertilizers, such as humic acids, have begun to be used at low concentrations in recent years to improve soil properties, nutrition for plants, accelerate growth and increase production (Zidan and Dayoub, 2005). Humic acid is one of the compounds of humus substance resulting from the decomposition of organic matter, which contains in its composition carbon, hydrogen, and oxygen in different proportions, resulting in compounds with different molecular weights. When these materials are added to the vegetative part of the plant, plays a fundamental role in plant nutrition (Burhan and AL-Taey, 2018), which is reflected in improving growth through their effect on photosynthesis and respiration processes, as they activate specific enzymes and inhibit other enzymes, as well as increasing the plant's resistance to harsh environmental conditions during the growing season and increased permeability of cell membranes, stimulate many biological reactions in the plant, and also lead to an increase in Cytokinin with increasing Auxin, and this acid helps improve nutrient absorption and helps retain water in the soil (Mousavi *et al.,* 2012). Humic acid stimulates many vital processes that lead to increased plant growth, as well as encouraging root growth, especially vertically, thus enabling the roots to better absorb for water and nutrients, it increases root respiration and the formation of root hairs and increases the development of chlorophyll, sugars and amino acids (Pettit and Robert, 2003; AL-Taey *et al*., 2019). Kaya *et al.* (2005) indicated that humic acid increases the permeability of membranes and enhances the absorption of nutrients N, P, K, Ca, and Mg and makes them more mobile and available to the plant root system. Poudineh *et al*. (2015) In a field experiment on sunflower plants it was found that the use of humic acid fertilization has a significant effect on the number of seeds per head; the total yield per unit area, and 1000 seeds weight. This study aims to know the best variety of sunflower crop and the best concentration of humic acid, as well as to know the best interaction between them to give the highest grain yield.

Materials and Methods

A field experiment was carried out during the spring 2020 season in Al-Huwair area, north of Basrah Governorate, in a silty clay Loam soil. Its physical and chemical characteristics are shown in Table 1. The experiment included spraying the nutrient humic solution (Humic acid 80% Humic) with four concentrations levels (0, 3, 6, and 9) mL/L^{-1} and using three cultivars of sunflower (Zahrat al Iraq, Aqmar and Flamme). The field experiment was conducted using the split - plot analysis technique according to a complete randomized block design with three replicates. The main plots are designated for the cultivars and the subplots for concentrations levels of humic acid solution. The area of the experimental unit was ($2\times3 = 6\ m^2$), and within each experimental unit were four lines, the length of the planted line 2 m, and the distance from one line to the next 75 cm and 30 cm between plant to plant in the same line. 3-4 seeds were planted in each hill, and it was reduced to one plant two weeks after germination. 1-meter distance between experimental units was left and 1.5 meters between blocks. The experiment field was fertilized with phosphate fertilizer 80 kg ha^{-1} in the form of triple superphosphate (46% P_2O_5), added in one batch at planting. As for nitrogen fertilizer, it was added in the form urea fertilizer (46% N) in two batches, the first at cultivation and the second at the flowering buds stage at 200 kg ha^{-1}, the cultivars seeds were planted on 10/2/2020, the rest of the agricultural operations like irrigation and weeding carried out for all treatments equally and as needed. The vegetative parts sprayed at two batches the first after 30 days from germination and the second batch after 30 days from first batch until full wetness in the early morning to avoid high temperatures, a 20-liter backpack sprayer was used. A diffuse substance (dish soap) was added in an amount of 1.5 cm^3 per liter with the nutrient solution for all experimental units. As for the control treatment, it was sprayed with water only with the diffuse substance. Ten heads were selected when reaching full maturity, and growth characteristics were studied, namely plant height (cm), stem diameter (cm), leafy area (m^2), number of seeds per head, weight of 1000 seeds, seed yield and oil percentage, estimated in plants harvested from the midline lines from each experimental unit, The data were statistically analyzed according to the design of the experiment and the mean of the treatments were calculated using the least significant difference test at a probability level of 0.05.

Table 1. Physical and chemical properties of field soil before planting.

Soil properties	Value	Unit
Sand	14	%
Silt	51	%
Clay	35	%
PH	7.3	
O.M.	0.93	g kg^{-1} soil
EC	3.8	dS m^{-1}
Available nitrogen	58	mg kg^{-1} soil
Available phosphorus	19	mg kg^{-1} soil
Aavailable potassium	141	mg kg^{-1} soil
Texture		Silty Clay Loam

Results and Discussion

Plant height

Table 2 findings show the significant impact of the cultivars, Concentrations of humic acids and their interaction at plant height, as Aqmar cultivar gave the highest plant height of (161.2) cm, while the Iraq flower cultivar recorded the lowest plant height of (150.0) cm, This is due to the nature of the genetic difference between the cultivars.

The highest humic acid concentration (9) mL/L^{-1} gave the highest average for this trait as it was (161.3) cm with a significant difference from the control treatment (0) ml l^{-1} that it gave the lowest average of (150.7) cm. This may be due to that humic acid contains major elements in addition to that it works on the readiness of nutrients that enter the process of making food and respiration and in the protoplasmic construction process, as it is involved in the synthesis of nucleic acids DNA and RNA necessary for cell division as well as the manufacture of hormones and Auxins, which in turn is important in cells division and elongation in the stem tissue and consequently increases in the plant height (Al-Sahaf, 1989). This is consistent with the findings of (Al-Shammari and Al-Zubaidi, 2017).

Stem diameter

Table 3 findings indicated the significant impact of cultivars, concentrations of humic acid, and the interaction between them in the stem diameter. Aqmar cultivar gave the highest stem diameter of (2.03) cm, while the Iraq flower cultivar recorded the lowest stem diameter of (1.58) cm. This is maybe due to the variation among cultivars in the genotype.

Leaf area

Table 4 findings show the significant impact of cultivars, concentrations of humic acids, and their interaction in the region of the leaves. Aqmar cultivar had the highest leaf area of (0.47) m^2 Whereas Iraq cultivar had the lowest leaf area (0.28) m^2. These findings may be due to the difference in genotype between cultivars. That is consistent with the (Abad

Table 2. Effect of the cultivars, humic acid concentrations, and their interaction on the plant height (cm).

Humic acid levels ml l^{-1}	Cultivars			Humic acid means
	Iraq flower	Aqmar	Flamme	
0	145.1	158.0	148.8	150.7
3	147.3	160.5	159.9	155.9
6	151.4	162.8	160.1	158.1
9	156.2	163.2	164.5	161.3
Cultivars means	150.0	161.2	158.3	
$L.S.D_{.(0.05)}$	Cultivars=7.725	Humic =3.88	Interaction= N.S.	

Table 3. Effect of the cultivars, humic acid concentrations, and their interaction on the stem diameter (cm)

Humic acid levels ml l^{-1}	Cultivars			Humic acid means
	Iraq flower	Aqmar	Flamme	
0	1.33	1.72	1.69	1.58
3	1.65	2.07	1.91	1.88
6	1.67	2.08	2.03	1.93
9	1.66	2.23	2.09	1.99
Cultivars means	1.58	2.03	1.93	
$L.S.D_{.(0.05)}$	Cultivars=0.246	Humic=N.S.	Interaction= N.S.	

Make, 2018) results. The high concentration of humic acid(9) mL/L^{-1} yielded the highest average of (0.49) m^2, while the control treatment (0) mL/L^{-1} yielded the lowest average at (0.25) m2 for this trait The reason may be attributed to the fact that humic acid has a positive effect on vegetable and root system growth and development and improved nutrient usage, which in turn led to an increase in the leafy area. As to the effect of the interaction between the cultivars and the concentrations of humic acid, Aqmar cultivar with (9) mL/L^{-1} concentration gave the highest average leaf area reached (0.69) m^2 whereas the Iraq flower gave the lowest average of (0.18) m^2 at the control treatment (0) mL/L^{-1}.

Head diameter

The results of Table 5 show the significant effect of cultivars, humic acid concentrations and the interaction between them in head diameter. Aqmar cultivar gave the highest head diameter of (18.28) cm, while the Iraq flower cultivar recorded the lowest head diameter of (10.89) cm. This difference between the cultivars in the head diameter may be due to the genetic difference between them. The high concentration of humic acid (9) mL/L^{-1} for this condition was the highest average as it was (16.21) cm compared to the control treatment (0) mL/L^{-1}, which was the lowest average of (10.89) cm. That may be because of the presence of humic acid in that head diameter. As for the effect of the interaction between cultivars and concentrations of humic acid, Aqmar cultivar at (9) mL/L^{-1} concentration level gave the highest average of (20.91) cm while Iraq flower cultivar gave the lowest average of (9.57 cm) in the control treatment (0) mL/L^{-1}.

Number of seeds head^{-1}

Table results (6) show the significant effect of the cultivars, Concentrations of humic acid and the interaction between them on number of head-1 seeds. Aqmar cultivar gave the highest number of seeds per head of (1269.00) seeds head^{-1}, while Iraq flower cultivar recorded the lowest number of seeds (992.08) seeds head^{-1}. The reason may be due to the nature of the genetic difference between cultivars.

1000 Seeds weight

Table 7 findings showed the significant impact of cultivars, the concentrations of humic acid and the interaction between them on 1000 seeds weight. Aqmar cultivar gave the highest 1000 seeds weight of (67.48) g, while Iraq flower cultivar recorded the lowest value of (60.62) g. This variation in this trait among cultivars could be due to the genetic difference between them. While the high concentration of humic acid (9) mL/L^{-1} for this trait gave the highest average as it was (71.75) g compared to treatment control (0) mL/L^{-1} which gave the lowest average of

Table 4. Effect of the cultivars, humic acid concentrations and their interaction on the leaf area (m^2)

Humic acid levels mL/L^{-1}	Cultivars			Humic acid means
	Iraq flower	Aqmar	Flamme	
0	0.18	0.29	0.27	0.25
3	0.29	0.41	0.39	0.36
6	0.31	0.48	0.44	0.41
9	0.36	0.69	0.43	0.49
Cultivars means	0.28	0.47	0.38	
L.S.D$_{.(0.05)}$	Cultivars=0.135	Humic=0.101	Interaction=0.18	

Table 5. Effect of the cultivars, humic acid concentrations and their interaction on the head diameter (cm)

Humic acid levels mL/L^{-1}	Cultivars			Humic acid means
	Iraq flower	Aqmar	Flamme	
0	9.57	14.30	10.64	11.50
3	10.59	17.37	13.06	13.67
6	11.19	20.55	15.99	15.91
9	12.21	20.91	15.52	16.21
Cultivars means	10.89	18.28	13.80	
L.S.D$_{.(0.05)}$	Cultivars=5.532	Humic=2.321	Interaction=5.748	

(55.32) g. Such results might be attributed to the role of humic and its consistency of elements in increasing the weight of 1000 seeds.

Seed yield

The results of Table 8 showed the significant effect of cultivars, the concentration of humic acids and their interaction on seed yield as the Aqmar cultivar gave the highest seed yield of (3357.25) kg/ha^{-1}. In contrast, the Iraq flower cultivar recorded the lowest seed yield of (2894.04) kg/ha^{-1}. These results may be due to the genetic difference among cultivars and the extent of the response to the environmental conditions. This is consistent with (Abad Make, 2018). The high concentration of humic acid (9) mL/L^{-1} for this feature was the highest average, as it was (3342.20) kg/ ha^{-1}, while the control treatment (0) ml l^{-1} recorded the lowest average of (2799.20) kg/ ha^{-1}. These findings may be attributed to the role of humic acid in boosting the leafy area and increasing photosynthesis efficiency and the transfer of processed materials to seeds and increasing their fullness, which was reflected in the increase in the seed yield. This is consistent with (Al-Shammari and Al-Zubaidi, 2017). As for the effect of the interaction between cultivars and humic acid concentrations, Aqmar cultivar recorded the highest average of (3642.75) kg/ha^{-1} at (9) mL/L^{-1} concentration level while Iraq flower recorded the lowest average of (2572.25) kg/ha^{-1} at control treatment (0) mL/L^{-1}.

Oil percentage

The results indicated in Table 9 the significant effect of cultivars, humic acid concentrations and the interaction between them on oil percentage. Aqmar cultivar gave the highest percentage of oil of (39.14)%, while the Iraq flower cultivar recorded the lowest oil percentage of (36.34)%. The difference between cultivars in the percentage of oil may be due to the difference in their genotype. This is consistent with (AL-Janabi and AL-Jebouri, 2017). While the high concentration of humic acid (9) mL/ L^{-1} was the highest average for this trait as it was (42.00) percent, the lowest average of (34.25) percent was recorded in the control treatment of (0) mL/L^{-1}. As for the effect of interaction between cultivars and concentrations of humic acid, the Flamme cultivar at (9) mL/L^{-1} concentration level gave the higher average of (42.54) percent, whereas the Iraq flower at (0) mL/L^{-1} concentration gave the lowest average as it was (31.34) percent for this trait.

Conclusion

Aqmar cultivar has recorded the highest average plant height, stem diameter, leaf area, head diameter, number of seeds per head, weight of 1000 seeds and yield of seeds and percentage of oil. The 9 mL^{-}

Table 6. Effect of the cultivars, humic acid concentrations and their interaction on a number of seeds head-1.

Humic acid levels mL/L^{-1}	Cultivars			Humic acid means
	Iraq flower	Aqmar	Flamme	
0	904.33	1238.17	947.00	1029.83
3	949.00	1241.60	1090.00	1093.53
6	1051.00	1257.24	1113.67	1140.64
9	1064.00	1339.00	1121.00	1174.67
Cultivars means	992.08	1269.00	1067.92	
L.S.D$_{.(0.05)}$	Cultivars=197	Humic=N.S.	Interaction= N.S.	

Table 7. Effect of the cultivars, humic acid concentrations and their interaction on 1000 seeds weight (g)

Humic acid levels mL/L^{-1}	Cultivars			Humic acid means
	Iraq flower	Aqmar	Flamme	
0	53.16	57.86	54.94	55.32
3	57.90	66.60	66.38	63.63
6	63.16	70.35	71.78	68.43
9	68.27	75.10	71.89	71.75
Cultivars means	60.62	67.48	66.25	
L.S.D$_{.(0.05)}$	Cultivars=4.33	Humic=10.12	Interaction=15.45	

Table 8. Effect of the cultivars, humic acid concentrations and their interaction on 1000 seeds yield (kg ha^{-1}).

Humic acid levels mL/L^{-1}	Cultivars			Humic acid means
	Iraq flower	Aqmar	Flamme	
0	2572.25	2982.35	2842.99	2799.20
3	2783.19	3170.08	3019.24	2990.84
6	3103.86	3642.75	3127.89	3291.50
9	3116.88	3633.83	3275.90	3342.20
Cultivars means	2894.04	3357.25	3066.50	
$L.S.D_{.(0.05)}$	Cultivars=285.6	Humic=399.6	Interaction=630.1	

Table 9. Effect of the cultivars, humic acid concentrations and their interaction on the oil percentage (%)

Humic acid levels $ml\ l^{-1}$	Cultivars			Humic acid means
	Iraq flower	Aqmar	Flamme	
0	31.34	36.55	34.86	34.25
3	33.95	38.37	36.95	36.42
6	38.36	39.92	39.49	39.26
9	41.73	41.72	42.54	42.00
Cultivars means	36.34	39.14	38.46	
$L.S.D_{.(0.05)}$	Cultivars=1.953	Humic=5.111	Interaction=7.772	

[1] concentration of humic acidl recorded the highest average of plant height, leaf area, head diameter, weight of 1000 seeds, seed yield and oil percentage. Aqmar cultivar recorded the highest average of leafy area, head diameter, 1000 seed weight and seed yield at (9) mL/L^{-1} concentration level, while Flamme cultivar recorded the highest oil percentage of (42.54) percent at (9) mL/L^{-1} concentration level.

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