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Effect of Foliar Nutrition by Humic and Fulvic Acid and the Interaction between them on Productivity of Sun Flower (*Helianthus annuus* L.)

Najm Abdullah Jumaah Al-Zubaidi and Baidaa Majeed Rashid Awaid

Department of Biology - College of Education for Pure Sciences – University of Diyala

baidaamjeed@gmail.com

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Abstract

The field experiment was carried out in one of the agricultural fields of Al-Khalis District / Diyala Governorate, Iraq, which is located 14 km north of Baquba District, during the autumn season of 2022, in soil with clay loam textured to study the effect of organic fertilization with humic and fulvic acid and the interaction between them on the growth and yield of the sunflower plants (*Helianthus annuus* L.). A two-factor experiment was carried out using three replications of the (RCBD) randomized complete block design. The first factor was sprayed with humic acid at a concentration of 6gm.L.$^{-1}$ And the second agent was sprayed with fulvic acid at a concentration of 6 gm.L $^{-1}$The results showed that there was a significant superiority when adding humic acid + fulvic acid at a concentration of 6gm.L.$^{-1}$ In the average characteristic of plant height, stem diameter, chlorophyll index, plant leaf area, number of leaves per plant,the weight of 1000 seeds, total yield, percentage of oil in seeds, and percentage of protein in seeds.

Keywords: humic acid, fulvic acid, organic acids, foliar nutrition, sunflower.

تأثير التغذية الورقية الورقية بحامض الهيوميك والفولفيك والتداخل بينهما على الانتاجية والغلة لنبات زهرة الشمس(*Helianthus annuus* L.)

نجم عبد الله جمعة الزبيدي و بيداء مجيد راشد عويد

قسم علوم الحياة – كلية التربية للعلوم الصرفة – جامعة ديالى

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الخلاصة

نفذت التجربة الحقلية في أحد الحقول الزراعية التابعة لقضاء الخالص \ محافظة ديالى الذي يقع على مسافة 14 كم شمال قضاء بعقوبة العراق خلال الموسم الخريفي للعام 2022، في تربة ذات نسجة مزيجية طينية loam Clay بهدف دراسة تاثير التسميد العضوي بحامض الهيوميك والفولفيك والتداخل بينهما في نمو وحاصل نبات زهرة الشمس *Helianthus annuus* L. نفذت تجربة عاملية ذات عاملين على وفق تصميم القطاعات العشوائية الكاملة RCBD وبثلاث مكررات .العامل الاول رش حامض الهيوميك بتركيز 6غم.لتر$^{-1}$,والعامل الثاني رش حامض الفولفيك بتركيز 6غم.لتر$^{-1}$.اظهرت النتائج وجود تفوق معنوي عند اضافة حامض الهيوميك +حامض الفولفيك بتركيز6غم.لتر$^{-1}$ في متوسط صفة ارتفاع النبات وقطر الساق ودليل الكلورفيل والمساحة الورقية للنبات وعدد الاوراق في النبات ووزن 1000بذرة والحاصل الكلي ونسبة الزيت في البذور ونسبة البروتين في البذور .

الكلمات المفتاحية : حامض الهيوميك، حامض الفولفيك، الاحماض العضوية، التغذية الورقية، زهرة الشمس.

Introduction

The sun-flower plant (*Helianthus annuus* L.) is belongs to the family Compsitae or Asteraceae, grown in subtropical and tropical regions with a dry to semi-arid climate, and its production is affected by drought in the stages of grain filling and flowering**[1],**and the plant is grown all over the world because it contains a high oil content and its ability to adapt to climatic conditions and different soils, the plant has many benefits and medical importance, and its grain meal is good fodder for farm animals **[2][3],**and its oil is considered one of the best healthy vegetable oils suitable for human nutrition because it contains Omega-3 fatty acid .In addition the high percentage of unsaturated fatty acids (Oleic, Linolenic, and Linoleic), which ranges between 85%-91%, while the saturated fatty acids (Palmitic and Stearic) do not exceed 15%, in addition to that it contains vitamins A and B. and E [4].

Humic substances are natural organic compounds obtained from decomposing plants and animals, soil, and organic manure. Humic acid is one of the components of humic substances. It stimulates plant growth and enhancing nutrient absorption as it affects the activity of enzymes, proteins, photosynthesis, respiration, and absorption of nutrients, water, nutrients, cell membrane permeability, components of electron chain transport, and free radical activity **[5].**Fulvic acid, the second most important humic substance, is one of the main biostimulants that improve plant production [**6**], and attracts water molecules, facilitates the movement of

nutrients into the roots, and acts as a mineral chelator[7]. Amino acids are among the important compounds that enter into plant growth, as they enter into protein synthesis through the formation of organic nitrogenous compounds as well as the synthesis of alkaloids, dyes and enzymes, and also work to activate cell growth, and store acidity in plant cells because they contain basic aggregates and acidic, and have their role in protecting cells from the high percentage of ammonia, which causes toxicity[8], and proline is one of the amino acids involved in the manufacture of protein, and it is one of the most important amino acids for plants because of its accumulation in plant tissues and has an important role in regulating The process of osmosis that occurs in the cell because it is concentrated in the cytoplasm and works on the balance of cellular osmosis, and works to protect all enzymes in conditions of water and salt stress, and a source of nitrogen and carbon, and it has an important role in the flowering and development of plants as the production of proline in plant cells maintains cellular balance , water absorption, osmotic modulation and redox balance to restore cell growth and mitigate oxidative damage[9].

Therefore, this study aims to:

1- Study the effect of spraying humic and fulvic acid individually on the growth and yield of a sunflower plants.

2- Study the effect of spraying a mixture of humic and fulvic acid on the growth and yield of a sunflower plant. .

Materials and methods

A field experiment was carried out during the autumn of 2022 in one of the agricultural fields of Khalis district in the Diyala Governorate.Iraq. A factorial experiment was carried out according to a randomized complete block design (RCBD) and with three replications in clay soil. Some of the physical and chemical properties of the study soil was determination table (1), the soil salinity 3.8 and acidity 7.3, while the texture of soil was clay loam, were conducted in the laboratory of the Diyala Directorate of Agriculture. The experiment included two factors. The first factor was foliar feeding with humic acid with concentration of 6gm.L^{-1} : Spraying

humic acid foliar on the shoots. The second factor is spraying fulvic acid foliar on the shoots, with a concentration of 6gm.L^{-1}. While the control group was spraying with distilled water only. The experimental treatments were sprayed on the shoots until complete wetness and in the early morning to avoid high temperatures. The area of the experimental unit was 2m^2, with four lines in one experimental unit, the distance between one pit and another is 25 cm, the distance between one line and another is 60 cm, and the distance between experimental units is 1 m, and between duplicates 2 m as well, and the plant density reached 66666 plants.ha $^{-1}$. The seeds were sown in the field on 19 /7/2022 by hand, with three seeds per bag pit. All experimental units were fertilized according to the fertilizer recommendation with phosphate fertilizer at a rate of 120 kg.ha^{-1} in the form of triple superphosphate 46% P_2O_4 mixed with the soil before planting. Nitrogen fertilizer was added at a rate of 320 kg.ha^{-1} In the form of urea fertilizer 46% N, it was added in two batches, the first after germination, and the second after one month from the first batch. While the potassium fertilization, it was added at a rate of 120 kg.ha^{-1} As potassium sulfate 46% K_2SO_4 at the beginning of the flowering stage[10]. The fungicide (Proplant) was added at a concentration of 72.2% three times throughout the growing season, as well as the insecticide (Cyprin,county of origin Jordan) was added once to control the whitefly. The vegetative characteristics of the plant were measured before flowering, and the yield characteristics of the plant were measured at the stage of maturity after 23/10/2022.

Table 1: shows some physical and chemical properties of agricultural soil.

ANALYSIS TYPE	SOIL PROPERTIES	UNIT
Soil salinity Ec	**3.8**	dsm^{-1}
Soil acidity pH	**7.3**	-----
Soil Texture	**clay loam**	
clay	**38.48**	%
silt	**34.30**	%
sand	**27.22**	%

Studied traits:

1. **Productive traits.**

Plant characteristics were calculated for the average of five plants randomly taken from the two middle lines of each experimental unit**.**

1-1. plant height (cm)

Plant height was measured using a measuring tape from the plant contact area with the soil to the base of the flower disc for five plants from the two middle lines, then an average was taken [11]

1-2. The number of leaves (leaf.plant^{-1}) : The number of total plant leaves in the flowering stage was calculated for five plants from each experimental unit, and then an average was calculated.

1-3. Stem diameter (mm).

Five plants were selected from each experimental unit, and the stem diameter was measured at the flowering stage from the middle of the stem by the foot (Vernier), then the average was calculated [12].

1-4. leaf area (cm^2) :

The leaf area was calculated at the flowering stage by calculating the sum of the squares of the maximum width of the leaves according to the mentioned method $\mathbf{LA=0.65\sum W^2}$ [13]. Where **W** represents the maximum width of the paper.

1-5. Leaf Chlorophyll Index (SPAD)-The leaf chlorophyll index was measured using a Minolta SPAD-502.

2. Yield traits

2-1. The weight of a thousand seeds (gm)

1000 full seeds were weighed by a sensitive scale.

2-2. Total Yield (ton.ha^{-1}).

It was calculated from (average yield per plant) x plant density. The weights were converted to tons.h^{-1} [10].

2-3. Protein percentage in seeds (%).

The percentage of protein in the seed pulp was estimated using the(MicroKejldahl made in Germany) device to estimate the percentage of nitrogen. The percentage of nitrogen was calculated, and then the percentage of protein was calculated using the following equation:

Percentage of protein = Percentage of nitrogen x 6.25. [14].

2-4. Percentage of oil in the seeds (%).

The percentage of oil in the seeds was estimated in the oil extraction device (Soxholet), and it is as follows, the percentage of oil according to the following equation. The percentage of oil in the= seeds Weight of the oil extracted from the seeds of the sample x100 Sample seed weight according to [15].

3. Statistical analysis.

The data were analyzed statistically for the results using the statistical analysis program (Genstat) according to the SAS analysis of variance as an experiment within the randomized complete block design, and the means of the treatments were compared according to Dunkin's multiple range test at the level of probability 0.05% [16].

Results and Discussion

Growth indicators

The results in Table (2) indicate that there are significant differences in the height of the sunflower plant when organic fertilizers are added, and the highest average of plant height was when spraying with humic acid + fulvic acid at a concentration of 6 gm.Liter^{-1}. Which amounted to 160.60 cm compared to the non-additive treatment, which amounted to 147.98 cm, with an increase rate of 8.52%. The direct cause may be attributed to the composition of organic acid, which is rich in essential nutrients, including nitrogen, phosphorus,and potassium, which have major roles in the process of carbon metabolism and respiration, and the increase of growth hormones, enzymes and accompaniments enzymes,and increase the formation of nucleic acids, DNA and RNA, which are necessary for the division and elongation of cells in the interstitial tissues of the stem, and thus increase the height of the plant, [17][18].While,there were insignificant difference in plant height when adding humic acid treatment and fulvic acid treatment severally, as the average plant height reached 156.31 and 155.56 cm, respectively. Spraying of humic and fulvic acid increases the uptake of monovalent ions such as ammonium and potassium by accelerating active uptake by plant roots[19].

The results in Table (2) indicate that there are significant differences in the number of leaves of sunflower plants when adding organic fertilizers, as the highest average plant height was when

adding humic acid + fulvic acid at a concentration of 6 gm. Liter^{-1} Which amounted to 38.81 leaf. plant^{-1} Compared to the treatment of no addition, which amounted to 33.68 leaf. plant^{-1} and the rate of increase amounted to 15.23%. The reason may be attributed to the role of humic and fulvic acid in causing an increase in the rate of leaves, due to their effect on stimulating the vital processes in plant tissues, such as the biosynthesis of photosynthesis products in the leaves, encouraging cell division and increasing their number, which leads to building the vegetative system and increasing the number of leaves [20].The results showed that there were insignificant difference when treating with humic acid and treating fulvic acid severally, as the number of leaves reached 37.51 leaf.plant^{-1}for each of them..

The results in Table (2) indicate that there are significant differences in stem diameter of sunflower plants when organic fertilizers were added, and the highest average stem diameter was when spraying with humic acid + fulvic acid at a concentration of 6 gm. Liter^{-1} which amounted to 21.57 mm, compared to the non-addition treatment, which amounted to 17.32 mm, with an increased rate of 24.53%.The reason may be that spraying organic fertilizers increases the availability of nutrients that encourage vegetative growth, and this is reflected in the increase in the diameter of the stem, as the increase in the diameter of the stem is the increase in the number of vascular bundles carrying nutrients and comes from increasing the thickness of the layer of bark and wood as well as the pulp, which it leads to increased utilization of the nutrients absorbed by the root,which. Giving more opportunitiesy for growth [20]. Also, the results showed that there were insignificant difference when adding the humic treatment and the fulvic acid treatment. The stem diameter was 19.29 and 19.41 cm, respectively.

The results in Table (2) indicate that there are significant differences in the leaf area of the sunflower plant when adding organic fertilizers, and the highest mean of the leaf area was when adding humic acid + fulvic acid at a concentration of 6 gm. Liter^{-1} which equivalent to 687.31 cm^2 .Compared with the control group, which amounted to 538.19 cm^2 ,with an increase rate of 27.70%, the reason may be attributed to the role of humic and fulvic acid in increasing the amount of major and micronutrients ready for absorption.Vegetative growth and increasing the effectiveness of meristems, and then increasing the leaf area of the plant, which allowed the

plant to use optimally those nutrients, which led to an increase in the rate of photosynthesis, which was positively reflected in the increase of the leaf area [21].

The results in Table (2) indicate that there are significant differences in the chlorophyll index of sunflower plants when adding organic fertilizers, and the highest average of the chlorophyll index was when adding humic acid + fulvic acid at a concentration of 6 gm.Liter^{-1} which amounted to 57.43 SPAD compared to the treatment of no addition, which amounted to 44.85 SPAD, and an increased rate of 28.04%. The reason is attributed to the role of organic fertilizers directly in increasing the antioxidants and preserving the chlorophyll content in the leaves from the catabolism process, as well as, it has an indirect effect on the soil through increasing the root system thus encourages the uptake of nitrogen and magnesium from the soil, which increase the chlorophyll content of the leaves [22][23].

Table 2: Effect of nutrition feeding with organic fertilizers on the average growth characteristics of sunflower plants.

Organic fertilization concentration	Plant height (cm)	Number of leaves (leaf, plant^{-1})	leg diameter (mm)	leaf area (cm^2)	Chlorophyll Index (SPAD)
without addition	147.98c	33.68b	17.32c	538.19d	44.85d
humic acid 6 gm.l^{-1}	156.31b	37.51a	19.29b	638.19c	48.95c
fulvic acid 6 gm.l^{-1}	155.56b	37.51a	19.41b	604.76b	52.37b
Humic + fulvic acid 6gm.L^{-1}	160.60a	38.81a	21.57a	687.31a	57.43a

Quantitative and qualitative traits.

The results in Table (3) indicate that there are significant differences in the weight of 1000 seeds of sunflower plants when adding organic fertilizers, and the highest average weight of 1000 seeds was when adding the treatment humic acid + fulvic acid at a concentration of 6 gm. Liter^{-1} Which amounted to 68.85 g compared to the treatment of no addition, which amounted to 63.17 g, and an increase rate of 8.99%. The reason may be due to the role of humic and fulvic acid in increasing the stimulation of plant growth and increasing its physiological effectiveness, which

led to an increase in the accumulation of dry matter and its transfer to the storage devices of the plant (seeds), which had a positive effect on grain weight gain [24][25].

The results in Table (3) indicate that there are significant differences in the total yield of sunflower plants when adding organic fertilizers, and the highest average of the total yield was when adding humic acid + fulvic acid at a concentration of 6 gm. Liter^{-1} which amounted to 4.50 tons. h^{-1} Compared to the non-addition treatment, which amounted to 3.47 tons. h^{-1} And the percentage of increase amounted to 29.76%, the reason may be due to the role of humic and fulvic acid in increasing the availability of nutrients and thus increasing their absorption by the plant and thus leading to improving vegetative growth and yield quality by increasing the diameter of the disc, the weight of a thousand seeds, the number of seeds in the disc and the yield of one plant and this In turn, it is positively reflected in the increase in the total yield, which contributed to a significant increase in it [26][27]. The results showed that there were insignificant differences in the total yield of sunflower plants when adding humic acid treatment and fulvic acid treatment, which amounted to4.03 and 4.09 tons.$^{-1}$ on the relay.

The results in Table (3) indicate that there are significant differences in the percentage of protein in the seeds of the sunflower plant when adding organic fertilizers, and the highest percentage of protein in the seeds was when adding humic acid + fulvic acid at a concentration of 6 gm. Liter^{-1} As it reached 17.50 %compared to the treatment of no addition, which amounted to 9.08%, and an increased rate of 92.73%, the reason may because of the humic and fulvic acids contain a high percentage of nitrogen and phosphorous, and this increases the activation of the activity of enzymes and increases sugars and amino acids, so these compounds are transformed into grains, and this is reflected positively on the increase The percentage of protein in grains [28][29].

The results in Table (3) indicate that there are significant differences in the percentage of oil in the seeds of the sunflower plant when adding organic fertilizers, and the highest average percentage of oil in the seeds was when adding the treatment humic acid + fulvic acid at a concentration of 6 gm. Liter^{-1} which amounted to 38.40% compared to the non-additive treatment, which amounted to 35.24%, and an increased rate of 8.96%. The reason may be due

to organic acid having an important role in increasing the permeability of nutrients through the cell membranes of plant cells and the amino and fatty acids it contains, which are the basis for the formation of oils [30][31].

Table 3: Effect of foliar nutrition with organic fertilizers on some quantitative and qualitative yield characteristics.

The concentration of organic fertilizers g.l-1	Weight 1000 seeds (gm)	The total yield (tons.h^{-1})	Percentage of protein in seeds (%)	Percentage of oil in the seeds (%)
without addition	63.17d	3.470c	9.08c	35.24d
humic acid 6 gm.L^{-1}	66.49c	4.038b	16.16a	36.71b
fulvic acid 6 gm.L^{-1}	67.03b	4.090b	12.54b	36.70c
Humic acid + fulvic acid 6gm.L^{-1}	68.85a	4.503a	17.50a	38.40a

Conclusions

We conclude from this study

The effect of foliar nutrition with humic acid and fulivc acid at a concentration of 6gm.L^{-1} each had a significant effect on all studied traids.The effect of foliar nutrition with humic,+ fulivc acid and interaction between them had a significant effect on all studied traids.

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