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Effect of Leafy Nutrition Humic Acid and Gibberellic Acid on Growth and Productivity of Barley

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Abstract. *Pots experiment was carried out during the 2018 – 2019 growing season to study the effect of humic acid (0, 3, and 6mg.L-1) and gibberellic acid (0,100 and 200 mg.L-1) leafy nutrition and their interaction with barley (Hordeum vulgare L.) growth and yield. The experiment was conducted as a randomized complete block design (RCBD) with three replicates, The means were compared at 0.05 according to the Least Significant Differential Test (LSD). The result showed a significant increase in plant height (cm), shoot dry weight (g), root dry weight (g), flag leaf area (cm2), spike length (cm), number of spikes per plant, number of spikelets per spike, 100 grains weight, grains yield (g / pot), and total chlorophyll content (SPAD), with increased concentration of Humic acid and gibberellic acid, and their interaction compared to control plants. Humic acid at 3 mg. L-1 and gibberellic acid at 100 mg. L-1 was the highest rate for all testing parameters.*

Keywords: *Barley, Humic Acid, Gibberellic Acid, Leafy Nutrition, Growth And Yield.*

I. INTRODUCTION

Barley (Hordeum vulgare L.) is from the family Poaceae (Graminae); After wheat, maize, and rice, it is the fourth most common food cereal in the world [1, 2]. It provides animals to feed, as well as human food and drink [3, 4]. Barley-produced food is a good source of many nutrients, including protein with its high nutritional value, rich in protein 9.9 g, fibers, selenium, minerals, and B-vitamins. [5] . as well as using it to reclaim saline soils[6] After wheat, barley is Iraq's second-largest cereal crop, with a similar growth season [7].

Because the barley plant is so important, it's crucial to enhance its growth and seed production. Plant growth regulators such as humic acid have been used to influence plant growth. humic acid (HA), is one of the most commonly used organic mineral fertilizers, plant growth, and yield have been shown to benefit from HA by regulating water and nutrient absorption, photosynthesis, protein synthesis, cell respiration, and enzyme activity [8], HA It's a commercial product made up of organic compounds derived from decomposition, microbial action on organic dead matter, and plant tissues [9], According to research, humic chemicals have a direct impact on plant metabolism, regulating ion transport, increasing absorption, enhancing respiration, and speeding up the enzymatic reaction of the Krebs cycle. [10-13]. a portion of humic matter arising from organic matter decomposition, Which contains carbon, hydrogen, oxygen, and nitrogen in different proportions, These materials play a fundamental role in plant nutrition when added to the vegetative group [14], As humic acid spraying on a plant increases its growth and improved phosphorus and other nutrient availability while also increasing yield [15], It is used in the early stages of plant growth as a source of multiple phenols, as enzyme system activity increases, the cell division, the development of the root system and the dry matter increase [16,17]. Experiments on numerous plants have shown that HA enhances plant growth both directly and indirectly, and in varying amounts for different plants [18,19]. HA has a direct and positive influence on wheat [20], and other plants such as chickpeas (Cicer arietinum) [21], and chicory (Cichorium intybus) [22], Treatment of wheat plants with humic acid resulted in an improvement in character growth and grain yield [23]. found that treatment with humic acid for wheat plants produced the highest mean levels for the number of spikes, biological yields, and grain yields [24,25].

One of the common methods in modern agriculture is the technique of using plant growth regulators (PGRs), Especially because they are used at very low concentrations, It allows plants to make very successful use of their physiological and genetic capabilities inherent in the use of nutrients, and are thus growth-specific and not nutritious [26], Plant growth regulators are chemical compounds that have been produced artificially, Exogenous treatment can influence plant growth and development [27]. gibberellic acid (GA3) has been used to affect the mitotic frequency or cell enlargement to regulate seed germination, Expansion and development of leaves, stem elongation, flowering, and fruit maturity [28-30]. So the study aimed to determine the best combination of humic and gibberellic acid to produce the highest yield and best barley growth.

II. MATERIALS AND METHODS

An experiment was conducted using pots during the summer growing season of 2018 – 2019 in a private nursery in Baghdad governorate to study the effect of leafy nutrition of humic acid (0, 3, and 6 mg. l-1) and gibberellic acid (0, 100, and 200 mg. l-1) and their interaction on growth and yield of barley (Hordeum vulgare L.) plant. The experiment was designed with three replications according to the Randomized complete block design (RCBD). So that the number of pots in the experiment reached 27 pots, ten grains were sown on pots on 17/11/2018, each containing 10 kg of dry soil, NPK (17:17:17) fertilizers were added before sowing at a rate of 1.6 g / pot in each pot, were thinned to six plants per pot after germination. After completing the fourth leaf, the plants were sprayed with

the concentrations of the humic and gibberellic acid solutions in the early morning until the complete wetness of the shoot groups. As well as spraying comparison plants with distilled water only. The spray was with gibberellic acid two days after the date of spraying with humic acid. Several drops of cleaning solution were added to the spray solution to reduce surface tension and achieve full wetness of the leaves. after 120 days, three plant samples were taken for growth and some physiological parameters from each pot, while the remaining three plants were left to determine yield and yield components by the end of the experimental period. growth and yield parameters studied were: plant height (cm), shoot dry weight (g), root dry weight (g), flag leaf area (cm2), spike length (cm), number of spike per plant, number of spikelets per spike, 100 grains weight, grains yield (g / pot), and total chlorophyll content was measured by the chlorophyll meter device (SPAD-502, Minolta, Japan). Statistical computations were carried out using the SAS software program [31] to investigate the treatment influence. The Least Significant Difference (LSD Test)(Variation-ANOVA Analysis) was used to significantly compare the mean with a probability of 0.05.

III. RESULT AND DISCUSSIONS

Table (1) shows that there are significant differences in the height of the barley plant due to the effect of spraying humic acid and gibberellic acid, The plant's height increased significantly when spraying with humic acid, as it reached 52.94 cm in 3 mg.L-1. while the control plants gave the lowest mean plant height of 48.54 cm. The same table results also showed that spraying with gibberellic acid resulted in a significant increase in the barley plant height, In plants treated with 100 mg.L-1, it reached 54.00 cm, while the control plants were 47.63 cm. The interaction of the two factors showed significant differences in the height of the barley plants, and the highest plant height value was 56.00 cm at 3 mg. L-1 humic acid and 100 mg. L-1 of gibberellic acid, while control plants gave the lowest average height of plants to 43.53 cm.

Table 1. The effect of humic acid and gibberellic acid spray and their interaction on plant height (cm)

HA mg. L^{-1}	GA_3 mg. L^{-1}			average of HA
	0	100	200	
0	43.53	53.90	48.20	48.54
3	51.43	56.00	51.40	52.94
6	47.93	52.10	49.90	49.98
average of GA_3	47.63	54.00	49.83	
LSD 0.05	GA_3	HA	Interaction	
	0.554	0.554	0.959	

The results (Table 2) also indicated that the humic acid treatments significantly affected the shoot dry weight, She gave the highest rate for the 3 mg.L-1 treatment was 2.58 g, while the control treatment gave the lowest dry weight rate at 1.92 g. The same table showed a significant increase in the average shoot dry weight when sprayed with gibberellic acid, It reached 2.59 g in plants treated with a concentration of 100 mg.L-1. The interaction of the two factors had a significant effect on shoot dry weight, and the highest value of this attribute was 3.01 g at 3 mg.L-1 humic acid and 100 mg.L-1 gibberellic acid, while the control treatment gave the lowest rate of 1.47 g.

Table 2. e effect of humic acid and gibberellic acid spray and their interaction on shoot dry weight (g)

HA mg. L^{-1}	GA_3 mg. L^{-1}			average of HA
	0	100	200	
0	1.47	2.34	1.96	1.92
3	2.61	3.01	2.11	2.58
6	2.31	2.43	2.01	2.25
average of GA_3	2.13	2.59	2.03	

LSD 0.05	GA_3	HA	Interaction	
	0.011	0.011	0.019	

The data (Table 3) indicated that spraying with humic acid and gibberellic acid reflected positively in the dry weight of the root, The spray of humic acid resulted in a significant increase in dry weight, with the treatment of plants above 3 mg.L^{-1} granting it the 1.45 g, The lowest dry weight at control plants was 0.96 g. gibberellic acid spraying has also resulted in a significant increase in this trait, The root dry weight was 1.43 g at a concentration of 100 mg.L^{-1}. The interaction effect of humic and gibberellic acid on this trait was significant, and the highest dry weight value was 1.70 g at 3 mg.L^{-1} humic acid and 100 mg.L^{-1} of gibberellic acid, while the control treatment gave the lowest rate for this trait to 0.42 g.

Table 3. The effect of humic acid and gibberellic acid spray and their interaction on root dry weight (g)

HA mg. L^{-1}	GA_3 mg. L^{-1}			average of HA
	0	100	200	
0	0.42	1.29	1.17	0.96
3	1.33	1.70	1.31	1.45
6	1.08	1.31	1.31	1.23
average of GA_3	0.94	1.43	1.26	
LSD 0.05	GA_3	HA	Interaction	
	0.006	0.006	0.011	

The means valve of data showed that the effect of humic acid and gibberellic acid and their interaction was significant on the flag leaf area as shown in Table 4, it was significantly increased with the highest value of 16.15 cm^2 at 3 mg.L^{-1} humic acid, while the comparative plants gave the lowest 14.24 cm^2. and it was highest values 16.52 cm^2 at 100 mg.L^{-1} gibberellic acid treatment, while the comparison treatment gave the lowest 13.78 cm^2. and their interaction significantly increased, It was 17.47 cm^2 with the highest value of 3 mg.L^{-1} humic acid, and 100 mg.L^{-1} gibberellic acid, While the comparative treatment gave 11.73 cm^2 at the lowest.

Table 4. The effect of humic acid and gibberellic acid spray and their interaction on flag leaf area (cm^2)

HA mg. L^{-1}	GA_3 mg. L^{-1}			average of HA
	0	100	200	
0	11.73	16.33	14.67	14.24
3	15.73	17.47	15.26	16.15
6	13.87	15.77	14.90	14.85
average of GA_3	13.78	16.52	14.94	
LSD 0.05	GA_3	HA	Interaction	
	0.127	0.127	0.219	

The data (Table 5) indicated that spraying with humic acid and gibberellic acid reflected positively in the spik length, the spray of humic acid resulted in a significant increase in spik length, with the treatment of plants above the 3 mg.L^{-1} granting it the 4.59 cm, the lowest dry weight at control plants was 3.76 cm. gibberellic acid spraying has also resulted in a significant increase in this trait, the spik length was 4.60 cm at a concentration of 100 mg.L^{-1}. The interaction effect of humic and gibberellic acid on this trait was significant, and the highest spik length value was 5.20 cm at 3 mg.L^{-1} humic acid and 100 mg.L^{-1} of gibberellic acid, while the control treatment gave the lowest rate for this trait to 3.40 cm.

Table 5. The effect of humic acid and gibberellic acid spray and their interaction on spike length (cm)

HA mg. L^{-1}	GA_3 mg. L^{-1}			average of HA
	0	100	200	
0	3.40	4.07	3.80	3.76
3	4.53	5.20	4.03	4.59
6	4.07	4.53	4.23	4.28

average of GA_3	4.00	4.60	4.02	
LSD 0.05	GA_3	HA	Interaction	
	0.113	0.113	0.195	

The results (Table 6) showed that there were significant differences between the average number of spikes per plant due to the spraying effects, The spray of humic acid resulted in a significant increase in the number of spikes, as it exceeded 6.22 spikes when treating 3 mg.L^{-1}, while comparative plants gave this trait the lowest number, it reached a spike of 4,67. The results of the same table also showed that gibberellic acid spraying resulted in a significant increase in the number of spikes, In treated plants with 100 mg.L^{-1} the spike reached 6.44, whilst 4.22 spikes for comparative plants. The interaction between the two factors showed significant differences in this trait of plants, the 3 mg.L^{-1} humic acid treatment with 100 mg.L^{-1} gibberellic acid was the highest in this trait, It reached a spike of 7.33, while the comparative plants gave 3.33 spike the lowest rate of this rating.

Table 6. The effect of humic acid and gibberellic acid spray and their interaction on the number of spike/plant

HA mg. L^{-1}	GA_3 mg. L^{-1}			average of HA
	0	100	200	
0	3.33	5.67	5.00	4.67
3	5.00	7.33	6.33	6.22
6	4.33	6.33	5.67	5.44
average of GA_3	4.22	6.44	5.67	
LSD 0.05	GA_3	HA	Interaction	
	0.666	0.666	1.154	

As the results (Table 7) showed that the good growth of the barley plant as a result of the spraying with positive effect factors also positively reflected the average number of spikelets per spike, The humic acid treatment gave this trait a significant increase, The treated plants with the 3 mg.L^{-1} give it the rate of 29.22, while comparative plants gave this trait the lowest rate, it reached 22.78. Spraying with gibberellic acid also resulted in a significant increase in this trait's rate, At a concentration of 100 mg.$L^{-1,}$ it reached 28.56 spikelets per spik, while 23.44 spikelets were used for the control treatment. The effect of interaction between humic and gibberellic acid has had a significant effect on this trait, treatment with 3 mg.L^{-1} humic acid and 100 mg.L^{-1} gibberellic acid giving it the highest spikelets number as it reached 31.67, while the comparative treatment gave the lowest rate to 19.67 spikelets per plant.

Table 7. The effect of humic acid and gibberellic acid spray and their interaction on the number of spikelets/spike

HA mg. L^{-1}	GA_3 mg. L^{-1}			average of HA
	0	100	200	
0	19.67	25.33	23.33	22.78
3	27.33	31.67	28.67	29.22
6	23.33	28.67	26.67	26.22
average of GA_3	23.44	28.56	26.22	
LSD 0.05	GA_3	HA	Interaction	
	0.751	0.751	1.301	

The data (Table 8) showed that humic acid spraying resulted in a significant increase in the weight of 100 grains, In plants treated with a concentration of 3 mg.L^{-1} it averaged 4.00 g, while control plants gave this trait an average of 3.22 g. The same table shows that the spraying with gibberellic acid increased the weight of 100 grains significantly, with the moral superiority of treated plants with 100 mg.L^{-1} by giving it the highest rate of 4.00 g compared to the control plants, which gave this trait the lowest rate of 3,33 g. The results of the interaction effects between humic and gibberellic acid showed a significant increase in this trait Since 3 mg.L^{-1} humic acid was sprayed with 100 mg.L^{-1} gibberellic acid, the highest rate was 4.67 g, while the control treatment gave the lowest rate of 2.67 g.

Table 8. The effect of humic acid and gibberellic acid spray and their interaction on 100 grains weight

HA mg. L^{-1}	GA_3 mg. L^{-1}			average of HA
	0	100	200	
0	2.67	3.67	3.33	3.22
3	4.00	4.67	3.33	4.00
6	3.33	3.67	3.67	3.56
average of GA_3	3.33	4.00	3.44	
LSD 0.05	GA_3	HA	Interaction	
	0.561	0.561	0.971	

The results (Table 9) indicated that spraying with humic acid and gibberellic acid has also been positively reflected in the rate of yield in grains, humic acid spray led to a significant increase in this trait with the superiority of plants treated with 3 mg.L^{-1} it has the highest rate of 15.34 g / pot, whereas the lowest yield of grains was contrasted with comparable plants, as it reached 12.62 g / pot. gibberellic acid spraying has also contributed to a significant increase in this trait, at a concentration of 100 mg.L^{-1} it reached 15.57 g / pot, while at the control plants 13.31 g / pot. The interaction of humic and gibberellic acid has had a significant effect on this trait with treatment above 3 mg.L^{-1} humic acid with gibberellic acid 100 mg.L^{-1} by giving it the highest yield in the grain of 16.91 g / pot, while the comparison treatment gave the lowest rate of 10.90 g / pot for this trait.

Table 9. The effect of humic acid and gibberellic acid spray and their interaction on grains yield (g / pot)

HA mg. L^{-1}	GA_3 mg. L^{-1}			average of HA
	0	100	200	
0	10.90	14.37	12.59	12.62
3	15.15	16.91	13.97	15.34
6	13.87	15.44	13.82	14.38
average of GA_3	13.31	15.57	13.46	
LSD 0.05	GA_3	HA	Interaction	
	0.252	0.252	0.436	

The results (Table 10) also indicated that the humic acid treatments significantly affected the total chlorophyll content, She gave the highest rate for the 3 mg.L^{-1} treatment was 25.71 SPAD, while the control treatment gave the lowest chlorophyll content rate at 23.71 SPAD. The same table showed a significant increase in the average chlorophyll content when sprayed with gibberellic acid, It reached 25.68 SPAD in plants treated with a concentration of 100 mg.L^{-1}. The interaction of the two factors had a significant effect on the plant chlorophyll content, and the highest value of this attribute was 26.37 SPAD at 3 mg.L^{-1} humic acid and 100 mg.L^{-1} gibberellic acid, while the control treatment gave the lowest value was 22.13 SPAD.

Table 10. The effect of humic acid and gibberellic acid spray and their interaction on chlorophyll (SPAD)

HA mg. L^{-1}	GA_3 mg. L^{-1}			average of HA
	0	100	200	
0	22.13	25.30	23.70	23.71
3	25.33	26.37	25.43	25.71
6	23.97	25.37	24.23	24.52
average of GA_3	23.81	25.68	24.45	
LSD 0.05	GA_3	HA	Interaction	
	0.094	0.094	0.163	

The increase in the traits studied is due to the positive effect that stimulates the growth of both humic and gibberellic acid, humic acid promotes nucleic acid metabolism, hormonal activity, activation of enzymes, changes in membrane permeability, synthesis of proteins, and activation of biomass production, and growth of plants by assimilating the micro and macroelements, Besides the effect of humic acid on respiratory and photosynthesis [32,33]. as well as which play a significant role in increasing development, growth, cell division, and the

development of roots[34]. That increases the carbohydrate substances produced in the leaves and their transfer to the fruit resulting in increased grain yield components [35]. These factors are used to describe the effect of humic acid on the growth parameters of plants. gibberellic acid also plays an important role in increasing cell division, and elongation, and stimulating their development by increasing cell wall plasticity [36]. and in increasing the catalyst plant content, which increases the level of oxine induced by the plant, cell division, building cell walls, and transporting and collecting nutrients, causing increased plant growth and development[36] . as well as its role in delaying the aging of tissues and increasing the total content of chlorophyll in the leaves, which leads to an increase in carbonization process [37].

IV. CONCLUSION

The barley plant's growth and yield parameters improved dramatically when providing leafy nutrition with humic acid, Spraying with gibberellic acid also led to a considerable improvement in all growth traits and yield parameters. The interaction between HA and GA3 produced a high rate for the traits studied, especially at 3 mg.L-1 of HA and 100 mg. L-1 of GA3.

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***Conflict of Interest Statement**:The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.*