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EFFECT OF SOIL FERTILIZATION WITH HUMIC ACIDS AND LEVELS OF NITROGENOUS MINERAL FERTILIZATION ON POTATO (*SOLANUM TUBEROSUM* L.) GROWTH AND YIELD

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Abstract

A field experiment was conducted during fall season 2018-2019 in one of the fields at the college of Agricultural Engineering Sciences-University of Baghdad-Al-Jadriya– Baghdad province in soil with silty loam texture to study the effect of soil fertilization with humic acids and levels of nitrogenous mineral fertilization on potato growth and yield (Reviera cultivar). The experiment was carried out according to the Randomized complete block design (RCBD) with three replicates. The experiment included two factors: the first is humic acids levels (O_0 without addition), (O_1 40 kg.ha^{-1}) and the second factor was nitrogen fertilization at four levels (N0 without addition), (N1 1/3 of the recommendation: 80 kg.ha^{-1}), (N2 2/3 two thirds of recommendation: 160 kg.ha^{-1}) and N3 (total fertilizer recommendation: 240 kg.ha^{-1}). The data were analyzed statistically and compared to the mean of the least significant differences (LSD) at the probability level (0.05). The treatments were randomly distributed on experimental units. The results of the study showed that the level of humic acid (O_1) had a significant effect on the plant characteristics. The treatment of N_3O_1 was superior compared to the rest of the treatments in plant height that reached 73.57 cm and the plant dry weight which was 7.92 ton.ha^{-1}, and elements concentration in leaves in maturity stage, Nitrogen concentration reached 2.60%, phosphorus reached 0.42% and potassium reached 3.82%, The percentage of dry matter in tubers was 20.72%. The results also showed significant differences in the characters of the tuber weight and the total singular plant weight and the total yield compared to the control treatment, where the interaction treatment of (N_2O_1) was superior in weight of the tuber. 167.57 gm.tuber^{-1}, singular plant yield 1097.0 gm.plant^{-1}, the total yield of tubers 58.53 ton.ha^{-1}, and the starch ratio that reached 13.65%.

***Keywords*:** Humic acids, Nitrogen mineral fertilization, potato crop, yield

Introduction

Humic acids have a key role in soil fertility and plant nutrition, positively affecting plant growth, such as increased permeability of cellular membranes, stimulation of enzymatic reactions, improved cellular division, and increased plant enzyme production (Pettit, 2003) due to pollution caused by mineral fertilizers for water, soil and air and the effects of excessive use of this fertilizer, particularly nitrogen, Agricultural producers have been using organic fertilizers to increase production in order to increase production and meet the increasing demands of food around the world and reduce the negative effects that may lead to harmful results and its role in increasing its economic returns and competition for normal production in world markets (Shakir *et al.*, 2014), potato is one of the most important vegetable crops belonging to the *Solanaceae* family and comes fourth as a strategic and economic crop after wheat, corn and rice. in Iraq and the world in terms of importance and cultivated area (Directorate of Agricultural Statistics, 2016). The world is moving towards clean farming technologies and minimizing pollution through the use of natural materials such as organic fertilizers or humic acids, as well as mineral fertilizers, which have led to the reduction of soil fertility and pollution. Humic acids have great importance in improving chemical properties of soil as they are of great importance in the complex chemical reactions that occur in the soil which positively affect the elements availability (Trevisan *et al.*, 2010). Tan (2004) confirmed that humic acids play an important role in increasing soil fertility, increasing enzyme activity, and increasing permeability of cell membranes to nutrients. Al-Zobaie 2000 and Bahia 2001 stated that the goal of adding and using mineral fertilizers is to increase soil fertility and to provide agricultural crops with nutrients, thus increasing the quantity and quality of production. Terhan *et al.* (2001) showed in their study on potato fertilization, used K, P and N at levels 240 kg N.ha^{-1} and 150 kg P_2O_5 .ha^{-1} and 180 kg K_2OH.ha^{-1} respectively and combinations (NP, NK, PK and NPK) the NPK combination was superior in plants height, the number of stems and in the leaves number.

Materials and Methods

A field experiment was conducted in one of the fields of the college of Agricultural Engineering Sciences Baghdad University-Al-Jadriya for the fall season 2018, using the Rivera cultivar of potato tubers, and then planted on 13 September 2018 in soil with silty loam texture. Table 1 (Some Physical and Chemical Soil Properties). The soil was prepared for agriculture and the plowing was done using a mold board plow and 25 cm depth. Then the first batch of mineral fertilizer was added according to the recommendation of the treatments. The urea % 46 N fertilizer was added as a nitrogen source and superphosphate 20% P fertilizer as a source of phosphorus and potassium sulfate 41.5% K as a source of potassium. Nitrogen mineral fertilizer was added at four levels (N0 without addition), (N1 1/3 of the recommendation : 80 kg.ha^{-1}), (N2 2/3 two thirds of recommendation: 160 kg.ha^{-1}) and N3 (total fertilizer recommendation: 240 kg.ha^{-1}). N, P and K mineral fertilizers were added (240, 120 and 400 kg.ha^{-1}) respectively (Fadli, 2006). Phosphate fertilizer was added to the soil as one batch when the soil prepared. While the Nitrogen and Potassium fertilizers were added in two equal batches the first after 20 days of planting and the second after 20 days of the first batch at the bottom of the furrow with depth and distance from the plant reached 10 cm. While the humic fertilizers were added to the soil in a single batch with nitrogen and potash fertilizer after 20 days of planting at two levels (without addition of O_0 and (O_1 40 kg.ha^{-1}) at the bottom of the furrow with depth and distance from the plant reached 10 cm. the experiment was carried out according to the Randomized Complete Block Design (RCBD) with three replicates as a factorial experiment including two factors the first factor is two levels of humic acid and the second is four levels of nitrogen mineral fertilizer. Thus, the number of treatments is 8 and the number of experimental units is 24.

Table 1 : Some physical and chemical properties of soil before planting.

Physical Properties				
Soil Bulk Density $Mg.m^{-3}$	**sand %**	**Clay %**	**Silt %**	**Texture**
1.4	22	25	53	silty loam

Chemical Properties			
(PH)	**Electrical Conductivity EC dc m^{-1}**	**Organic matter $gm.kg^{-1}$.soil**	**Cation exchange capacity (CEC) $cmol_c.kg^{-1}$**
7.5	2.16	4.15	22.1

Available nitrogen $gm.kg^{-1}$.soil	**Available phosphor $gm.kg^{-1}$.soil**	**Available potassium $gm.kg^{-1}$.soil**
35	9.0	140
Calcium $mmol.L^{-1}$	**Magnesium $mmol.L^{-1}$**	**Sodium $mmol.L^{-1}$**
5.81	3.62	2.01

Table 2 : Characters of humic acids used in the study

Character	Value	measuring unit
Humic Acid	68	%
Fulvic Acid	17	%
N	6.5	%
P	0.61	%
K	4. 8	%

Results and Discussion

The results of Table (3) showed that the plant height increased by increasing levels of N1, N2 and N3, respectively by 11.06, 25.84 and 38.31% compared to the control treatment N0. The addition of O_1 humic acid fertilizer significantly increased plant height by 4.64% compared to the O_0 control treatment. With the highest rate of plant height reached 73.57 cm in the interaction treatment of N_3O_1 compared to the lowest value 49.40 cm that obtained from interaction treatment N_0O_0 by 48.92%.

Table 3 : Effect of soil fertilization with humic acids and levels of nitrogenous mineral fertilization on plant height (cm).

Nitrogenous Mineral Fertilization	Humic Acids		Mean
	O_0	O_1	
N_0	50.33	53.60	51.97
N_1	55.50	59.93	57.72
N_2	64.92	65.88	65.40
N_3	70.60	73.15	71.88
Mean	60.34	63.14	
L.S.D	**N 1.54**	**O 1.09**	**O×N 2.18**

Total Leaf Area (dm^2 $plant^{-1}$)

The results of the statistical analysis showed that the values of leaf area increased by increasing the levels of nitrogen fertilization N1, N2 and N3, with by 20.70, 21.57 and 30.57% respectively compared to control treatment N_0. The addition of humic acid (O_1) significantly increased the leaf area by 3.90% compared to the O_0 treatment. As for the effect of binary interaction, the interaction treatment of (N_3O_1) was superior by giving the highest value of leaf area reached 145.49 dm^2 .$plant^{-1}$ compared to the lowest value of leaf area 96.34 dm^2.$plant^{-1}$ which obtained from the control treatment N_0O_0 by 51.01%. The significant effect of humic acid in the values of the study indicators may be attributed to its direct effect in providing the energy needed to increase the division, size and number of cells, which leads to increased plant growth.

Table 4 : Effect of soil fertilization with humic acids and levels of nitrogenous mineral fertilization on total leaf area(dm^2.$plant^{-1}$).

Nitrogenous Mineral Fertilization	Humic Acids		Mean
	O_0	O_1	
N_0	104.95	112.89	108.92
N_1	127.64	131.80	129.72
N_2	132.31	137.19	134.75
N_3	139.93	144.50	142.21
Mean	126.20	131.95	
L.S.D	**N 4.24**	**O 3.00**	**O×N 6.00**

This is reflected in the growth of the roots and increase the permeability of the cell wall and the increase of their branches, which leads to increased permeability and absorption of nutrients in the plant. And thus positively affect the process of photosynthesis, which leads to increased composition of nucleic acids and proteins, which lead to increased plant height and leaf area. these results in agreement with results (Mohamed, 2012 and Gomaa *et al.*, 2014). As well as the significant effect of the added levels of nitrogen mineral fertilization in plant height and leaf area resulting from the effects of nitrogen fertilizer in the increase and cells division in meristematic tissues, as it is an essential elements and participation in most components of the living cell and its role in the plant by increasing the creation of amino acids and the consequent increase in plant height.

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

The results of Table (5) indicate to increase in the total yield with increase of nitrogen levels N1, N2 and N3, by giving a total tubers yield reached 49.83, 52.87 and 52.70 $ton.ha^{-1}$ with an increase by 20.97, 28.35 and 27.94% respectively. Compared to the lowest total tubers yield obtained from control treatment N0, which reached 41.19 $ton.ha^{-1}$, also the addition of humic acids (O_1) significantly increased the total tubers yield that reached 50.44 $ton.ha^{-1}$, by 5.39% compared to the control treatment (O_0) which gave 47.86 $ton.ha^{-1}$.

The effect of the binary interaction between nitrogenous mineral fertilization and humic acids showed significant differences that the interaction N_2O_1 had the highest total tubers yield reached 55.43 ton.ha^{-1} compared to the lowest total tubers yield 38.20 ton.ha^{-1} which obtained from interaction treatment N_0O_0 by 45.10%. Shaaban (2009) states that humic acids play an important role in increasing potato production in terms of quality and quantity.

Tan (1986) also confirmed that humic acids played an important role in increasing soil fertility, increasing enzyme activity, increasing the permeability of cell membranes to nutrients. The effect of fertilizers interaction was significant in these characters. This is due to the role of integration between humic fertilizers and mineral fertilizers which resulted in a good construction of the plant and then the activities of physiological and vital, resulting in a good stock of tubers, which improves the quantitative qualities. This result is in agreement with results of some researchers when the addition of compost manure with the mineral fertilizer to the soil planted with potato crop, including (Kopple, 2001 and Farhan, 2008).

Table 5 : Effect of soil fertilization with humic acids and levels of nitrogenous mineral fertilization on total tubers yield (ton.ha^{-1}).

Nitrogenous Mineral Fertilization	Humic Acids		Mean
	O_0	O_1	
N_0	38.20	44.17	41.18
N_1	49.73	49.93	49.83
N_2	50.23	55.43	52.83
N_3	52.00	53.39	52.70
Mean	47.54	50.73	
L.S.D	**N 1.37**	**O 0.97**	**O×N 1.93**

Tubers Dry Matter %

The results of Table (6) showed that the percentage of dry matter increased by increasing the levels of nitrogen fertilization at levels N1, N2 and N3 by 9.70, 25.22 and 33.35%, respectively compared to control treatment. the addition of humic acid (O_1) was significant in dry matter percentage with an increase of 4.41% compared to the O_0 treatment. The effect of binary interaction was significant in this character. The treatment N_3O_1 gave the highest dry matter percentage reached 19.61% compared to the lowest ratio 14.53% that obtained from interaction treatment N_0O_0 by 34.96%. The increase due to the addition of humic fertilizer and nitrogen fertilizer levels in these characters may be attributed to the role of organic fertilizer in increasing the availability of macro and micro nutrients. So that it can be easily absorbed by the plant so that the plant can build a good root mass that can absorb the nutrients well to build a good vegetative growth and the activation of the various vital activities of plants and photosynthesis as the plants did not suffer from a shortage of these nutrients, which leads to retention of nitrogen and increase the dry matter of the tubers, which leads to increase the proportion of protein and starch and dry matter in the tubers because of the correlation between them, and there are similar results obtained by (Algoboori and Sahan, 2006 and Kademi, 2017).

Table 6 : Effect of soil fertilization with humic acids and levels of nitrogenous mineral fertilization on tubers dry matter %.

Nitrogenous Mineral Fertilization	Humic Acids		Mean
	O_0	O_1	
N_0	14.53	14.73	14.63
N_1	15.76	16.34	16.05
N_2	17.32	19.33	18.32
N_3	19.42	19.61	19.51
Mean	16.76	17.50	
L.S.D	**N 4.24**	**O 3.00**	**O×N 6.00**

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