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Response of four Varity of potato (*Solanumtuberosum L.*)to different concentration of Humic acid under Plastic houses conditions.

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Abstracts:

This study was carried out during the Agricultural season 2016 -2017 in the College of Agriculture/ University of Dohuk /Kurdistan region/ Iraq to study the effect of spraying Humic acid at three concentrations i.e. (0, 9 and 18ml.L^{-1}on four cultivars of potato(*Solanumtuberosum L.*) i.e.(Sifra, Ravila, Silvana and Fabyoula) that grown under plastic houses conditions.

The results indicated that the all cultivars was good in vegetative growth, quality and yield characteristic especially cultivars Rvillo that gave high yield per plant and per square meter significantly, compared with other cultivars. Also spraying plant with a concentration 18ml.L^{-1} of humic acid with all cultivars gave goodresults especially in Ravillo cultivars compared with unsparing plant that gave the lower yield and less tuber number per plant.

Keywords:Cultivars, Potato, Humic acid

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Introduction:

Potato (*Solanumtuberosum L.*) is one of the most important vegetable crops in Iraq and in the world. It belongs to the Solanaceae family,.and considered as one of the most important vegetable crops in many regions of the world. It is the second vegetable crop after tomato according to the cultivated area and one of the most important exported crops. It is rich of nutrients but its production in Iraq is still very low. Potato is the world's fourth largest food crop where it plays an important role as a staple food in the Iraq. The crop occupied an overall area about 1 million hectares which produced 28 million tons of tubers (13).

It is considered as a rich crop of nutrient substances and is consumed very large quantities as manufactured, each 100g of potato peeled tubers contain 79.80g. water, 76 calories, 2.10 gm protein, 0.1gm lipids, 17.1gm carbohydrates, 0.5gmfibers and 0.9gm ash as well as it contains a little quantity of nutrient elements and some vitamins, it contains 0.1 mg thiamin, 0.4 mg Riboflavin, 1.5 mg Niyasin and 20.0 mg Ascorbic acid (16). The last recorded statistical productivity revealed that potato production was only 3.992 tons. Donum^{-1} , potato Where compose as daily food for more than 75% of word (28).

The problems of Iraqi soils that characterized with the basic nature and its poorly in organic matter and what is associated with it of nutrient elements fixation and then effect on yield of crops, so it is necessary to search for other ways for plant nutrition, like the use of bio-and organic fertilizers.

The excessive use of chemical fertilizers has polluted the environment to a great extent and the food produced under such a farm management may not be safe. Public awareness of these problems has shifted the approach towards some alternative measures(33).Humic substances

can improve water holding capacity for better drought resistance and reduction in water usage (27).It is necessary to increase the production of unit area by using natural techniques including natural methods of nutrition to increase the productivity and improve its quality. In traditional culture, adding chemical fertilizers is highly for plant since it is expensive and not economic as well to its damages for its using. Since it is considered as compounds were that leaving its damages effect on human and its ecology quickly or in far period and from this new technique using bio and organic fertilizers.

Humissubstances have also a major contribution in soil fertility maintenance and plant nutrition(8 and 21). Hummus substances are a heterogeneous mixture of naturally occurring organic materials that arise from the decay of plants and animal residues. These Humic substances in soil are commonly referred to as organic matter or humus. Humus is comprised of three distinct groups namely, Humic acid, Fulvic acid andHumin.In general, increasing humus level has a number of benefits for plants i.e. increasing water holding capacity and soil warmth via the dark color that absorbs light energy and act as a glue to improve soil aggregation, Piccolo *et. al*.(23)also reported that plants grown on soils containing adequate Humic and Fulvic acids are less subject to stress and are healthier and produce higher yields (24 and 31). David *et.al.*(11) in an experiment on tomato transplants growing in nutrient solution contained different concentrations of Humic acid, reported an enhanced and induced effect on transplants growth and increasing its mineral structure, and this was agreed with the results of Adani*et. al.*(3) on tomato plants, which found that humic acid increasing plant growth and its mineral content.Humic acid possesses high capability in controlling soil

pH against changes which might occurs from the use of chemical fertilizer (17).

One of the used organic -mineral fertilizers is humic acid. Humic acid is one of the major components of humic substances. Humicmatter is formed through the chemical and biological humification of plant and animal matter and through the biological activities of micro-organisms Under water stress, foliar fertilization with humic molecules increased leaf water retention and the photosynthetic and antioxidant metabolism(14).Humic acid induce soil micro organisms like bacteria and fungi and provides carbon as a source for the organisms humic acid as well acting as chelating material, and reason the lack of mineral nutrient and losing them by leaching and also make many nutrient available in soil such as phosphate, calcium and trace elements and finally humic acid posses high capability in controlling soil pH against changes which might occur from the use of chemical fertilizers(29). The benefits of humic substances in agricultural soils is well established(19) especially in soils with low organic matter(9).Humic acids are heterogeneous, which include in the same macromolecule, hydrophilic acidic functional groups and hydrophobic groups. humic acid have been shown to stimulate plant growth and consequently yield by acting on mechanisms involved in: cell respiration, photosynthesis, protein synthesis, water and nutrient uptake, enzyme activities(10). Also it enhances plant growth and soil microorganisms like bacteria, fungi and provides carbon as a source of it and its good as a chalet substance, reducing some nutrients and leaching, losing and providing many nutrient for soil like calcium, phosphorus and micronutrient and it has a high ability on soil pH controlling against changes resulted by adding mineral fertilizer(17), also

it supply growing plants with food, make soil more fertile and productive it helps plants to resist drought and stimulate seed germination , it is also reduces other fertilizer requirements, increase yield in crops, improve drainage, increase aeration of the soil, increase the protein and mineral content of most crops and establishes a desirable environment for microorganisms development(5).

Several research studies have been carried out in this regard in general and especially in Kurdistan region that done in the farm therefore, to get early yield with good quality this experiment was conducted under plastic houses to study the effect of humic acid on the growth, and yield characters of some cultivars of Potato(Sifra, Ravila, Silvana and Fabyoula).

Materials and Methods:

An experiment was conducted at the Vegetable Research, Horticultural Department, College of Agriculture, University of Dohuk, Iraqi Kurdistan region, during autumn season of 2016,under plastic houses to study the response of potato cultivars to Humic acid., tuber were planted in 15 November 2016 in the soil during autumn season. The land was plowed and the soil softened, then divided into ridges 70cm with 2 m tall., then soil irrigated and there after potato tubers were sown at distance of 30 cm. tubers of were planted under plastic house. Randomized Complete Block Design (R.C.B.D) were used that conducted with two factor and three replicated, first spraying Humic acid at three concentrations i.e. (0, 9 and 18ml.L^{-1}), second was four cultivars (Sifra, Ravila, Silvana and Fabyoula), each replicated was represented by three ridges. Humic acid (liquid) was Spraying three times within 15 days interval. Uniform cultivation practices were followed according to commercial farmers. Data were analyzed by using SAS program(32 and 5)

The recorded data was taken after in March 2017 were as following: Vegetative characteristics that include Plant height (cm), number of aerial stems, content of total chlorophyll in leaf(S.P.A.D), leaf area cm^2, leaf number per plant, and quality characters which include, tuber (diameter and length) cm and yield character which include tubers number per plant, tuber weight (gm) tuber yield gm per plant, total yield $kg.m^{2-1}$.The soil of the study location was clay. The depth of water table was more than two meters. Random samples of the plastic house soil were taken from different sites of the field at a depth (30 cm), air dried and then passed through 2.0 mm sieve for determining some physical and chemical properties of soil, which is shown in Table(1).

Results:

Vegetative Growth Characters.

Content of total Chlorophyll

Table (2) shows the effect of spraying humic acid on total chlorophyll (S.P.A.D.) it showed that the total chlorophyll content in the leaves was significantly increased between the cultivars. Its shows that humic acid alone don't shows significant increase differences in chlorophyll content. The interaction between humic and cultivars showed significant increased in chlorophyll content Sifra and Silvana cv give higher value of chlorophyll content compared to other cultivars., the highest value appear between humic acid and Silvana with $9(ml.L^{-1}$)and the variety showed significant increase in total chlorophyll content the highest value was 41.22 (S.P.A.D.) in as compared with the least values of the above parameters recorded with interaction between ravilo with control that gives lowest value of chlorophyll content (35.40**) (**S.P.A.D.).

Table (1): Some physical and chemical characteristics of the field studied soil

Characteristics	Measuring units	2010
Volumetric distribution of soil separate		
Sand	(%)	8.4
Silt	(%)	38.38
Clay	(%)	55.72
Texture	---	Clay
Available nutrient content		
Total –N	(%)	5.55
Available phosphorus	Ppm	4.0.7
Available potassium	Ppm	33.75
Organic matter	(%)	1.89
pH	1:1 in suspension	6.89
Electrical conductivity	($ds.m^{-1}$)	0.64

*The analysis was carried out at soil and water science laboratory, College of Agriculture, Duhok University.

Leaves area (cm^2).

Data in Table (3) showed that there are no significant differences in the leaves area in cultivars .,furthermore plant treated with humic acid gave the highest value for the average of the leaves area compared with control..The interaction between the spraying humic acid with cultivars had a significant effect on the average of leaf are the highest value for the average leaf area ($9.92cm^2$)

was observed in plant treated 9ml.L^{-1} with Silvana cv. as compared with controls ×cultivars. The lowest value of leaves area was between control× Sifra cultivars that gave (6.02)cm^{2}.

Table (2): Effect ofhumic acid, and their interactions on content of total Chlorophyll in leaf.

Cultivars	Humic acid			Effect
	0	9(ml.L^{-1})	18(ml.L^{-1})	of cv.
Sifra	37.80ae	39.64ac	40.23ab	39.23a
Ravilo	35.40de	34.98e	36.98be	35.79b
Silvana	39.34ad	41.22a	39.30ad	39.96a
Fabyoula	36.69be	36.84be	36.23ce	36.59b
Effect of Humic	37.31a	38.17a	38.19a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

Branch Number.plant^{-1}.

Table (4).Shows the effect of spraying humic acid on branches number.plant^{-1}. It showed no significant difference in the branch number.plant^{-1} between all cultivars also table (3) shows the effect of spraying, humic acid concentration on branch number treating plant with 18ml.L^{-1} of humic acid on branches number.plant^{-1} .,gave higher number of branch per plant compared with other concentration of humic acid .concerning the interaction

between the humic acid and cultivars showed significant increase in the branch number .plant^{-1} plant receiving 18ml.L^{-1} 0f humic acid withFabyoula cultivars gave high number of branch compared with other treatment Regarding the interaction between control and cultivars gave lower number of branch .plant^{-1} for all cultivars .

Table (3): Effect ofhumic acid, and their interactions on leaves area.

Cultivars	Humic acid			Effect
	0	9(ml.L^{-1})	18(ml.L^{-1})	of cv.
Sifra	6.02bc	8.17ac	7.83ac	7.47a
Ravilo	6.60bc	8.42ac	8.50ac	7.86a
Silvana	7.88ac	9.42a	8.85ab	7.58a
Fabyoula	7.08ac	7.50ac	8.75ab	7.78a
Effect	6.60b	8.38a	8.048a	

of Humic

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

Leaves Number.Plant^{-1}**.**

The results in Table (5) showed that there are significant difference among cultivarsFabyoula cultivars gave higher value of leaves number per plant compared with other cultivars whereas the treating plant with 18m.L^{-1} gave higher number of leaves (80 leaves.plant^{-1})compared with other concentration that gave lower number of leaves . plant^{-1}

concerning the interaction between the humic acid and cultivars The highest leaves number per plant was showed in plant treated with 18ml.L^{-1} withFabyoula cultivars compared with control treatment

Table (4): Effect ofHumic acid, and their interactions on branch number

Cultivars	Humic acid			Effect
	0	9ml.L^{-1}	18 ml.L^{-1}	of cv.
Sifra	4.33c	6.33ab	8.93ab	6.53a
Ravilo	4.67c	6.33ab	8.47ac	6.49a
Silvana	4.33c	6.00b	9.77a	6.70a
Fabyoula	4.33c	6.33ab	10.17a	6.94a
Effect of Humic	4.4c	6.25b	9.33a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

Qualitative Characters.

Tuber Length(cm).

Results in Table (6) showed that there are no significant increase in tuber length among the tuber the higher length was in Silvana cultivars compared with other cultivars.treating plant with (9and 18)ml.L^{-1} gave higher length of tuber compared with the control that give lower length of tuber.the interaction between treatment the best interaction was when treating plant with 9 ml.L^{-1} of humic acid with Silvana cultivars compared

with the untreated plant that give lower length of tuber .

Table (5): Effect ofhumic acid, and their interactions on leaves number

Cultivars	Humic acid			Effect
	0	9(ml.L^{-1})	18(ml.L^{-1})	of cv.
Sifra	45.67df	48.00cf	68.67be	54.11ab
Ravilo	44.33ef	74.67ac	73.00ac	64.00ab
Silvana	46.00df	58.33bf	80.33ab	61.56ab
Fabyoula	62.02f	61.00bf	98.00a	73.67a
Effect of Humic	49.58c	60.50b	80.00a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

Tuber Number.plant^{-1}

Table (7), showed no significant increase in tuber number per plant for all cultivars the higher number of tuber was in Silvana cultivars compared with other cultivars. treating plant with (9 and 18 ml.L^{-1}) of humic acid gave (8.17 and 10.60)tuber .plant $^{-1}$humic acid respectively compared with untreated plant(5.33)tuber.plant^{-1} .

Concerning the interaction between humic acid and cultivars the interaction between 18ml.L 0f humic acid with Fabyoula cultivars gave higher number of tuber per plant compared with all cultivars non treated with humid acid that gave lower number of tuber per plant(12 tuber)compared

with untreated plant in Fabyoula (4.6)tuber per plant.

Table (6): Effect ofhumic acid, and their interactions on tuber length.

Cultivars	Humic acid			Effect
	0	9($ml.L^{-1}$)	18($ml.L^{-1}$)	of cv.
Sifra	7.30bc	8.47ac	8.93ac	8.23a
Ravilo	7.60ac	9.13ac	8.47ac	8.40a
Silvana	7.20bc	10.43a	9.77ac	9.13a
Fabyoula	6.87c	8.23ac	10.17a	8.42a
Effect of Humic	7.24b	9.07a	9.33a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

Tuber Diameter (cm).

Concerning the tuber diameter table (8), showed that there are significant increase between cultivars ., Ravilo cv. Gave higher diameter per tuber (7.01mm.tuber^{-1} compared with other cultivars, treating plant 18ml.L of humic acid gave higher diameter of tuber per tuber.Concerning the interaction the best interaction was showed in the interaction between Ravilo with 18ml.L of humic acid compared with Sifra and Fabyoula with control that gave lower diameter of tuber (4.00 and 4.63)mm .tuber respectively.

Table (8): Effect ofhumic acid, and their interactions on tuber diameters .

Cultivars	Humic acid			Effect
	0	9ml.L^{-1}	18 ml.L^{-1}	of cv.
Sifra	4.00d	4.83cd	7.83ac	5.56b
Ravilo	5.65ad	6.87ab	8.50a	7.01a
Silvana	4.40cd	6.23bc	7.08ac	5.91b
Fabyoula	4.63cd	6.03ac	8.75ab	6.47b
Effect of Humic	4.67bc	5.99b	8.04a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

Quantitative Yield Characters.

Tuber weight (g.tuber^{-1}).

Results from table (9) showed that Ravilo and Fabyoula gave higher weight of tuber compared with Sifra that gave lower value of tuber weight (127.64g.tuber^{-1}). concerning the effect of humic acid plant treated with 18 ml.L gave higher weight of tuber (207.43) compared with the untreated plant that gave lower weight of tuber 157.91gm.

Regarding the interaction the best interaction was shown in Ravilo with 18ml.L^{-1} of humic acid that gave (129.77g,L-1) compared with the interaction between Sifra with untreated plant that gave the lower value of tuber weight (90.73g.L-1).

Table (9): Effect ofhumicacid, and their interactions on tuber weight

Cultivars	Humic 0	Humic 9g.L^{-1}	Humic 18g.L^{-1}	Effect of cv.
Sifra	90.73b	123.67ab	168.53ab	127.64b
Ravilo	206.40ab	173.70ab	229.77a	203.29a
Silvana	140.33b	197.03ab	185.10ab	174.15a
Fabyoula	194.20ab	166.57ab	246.30a	202.36a
Effect of Humic	157.91b	165.24a	207.43a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

Plant yield (kg.plant^{-1}).

Data from table (10) indicated that there are no significant increase among cultivars but their the high tuber weight was from Ravilocultivars that gave more tuber weight compared with other cultivars that gave lower value . Concerning the treatment there are no significant different among all treatment the lower tuber weight was from plant untreated of humic acid (control) that gave (9 g.L^{-1}), concerning the interactions., the interaction among Ravilo, Fabyoula cultivars and concentration 18ml.L^{-1} of humic acid gave higher tuber weight compared (2.33 and 1.23) kg.plantr^{-1} .compared with the untreated plant with humic acid (control).

Table (10): Effect ofhumicacid, and their interactions on the plant yield

Cultivars	Humic acid			Effect
	0	9g.L^{-1}	18g.L^{-1}	of cv.
Sifra	0.80b	1.40ab	1.03ab	1.28a
Ravilo	0.98b	2.03ab	2.33a	1.78a
Silvana	0.99b	0.77b	1.00ab	0.99a
Fabyoula	0.87b	1.20ab	1.23ab	1.10a
Effect of Humic	0.91a	1.35a	1.39a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

Total yield (kg.plant^{-1}).

Data from table (11) indicated that there are significant increase among cultivars the cultivars was Ravilocomparwed with Silvana that get loweryield per plant **(**13.60 and 7.64) respectively., concerning the effect of humic acid treating plant with (9 and 18)ml.L^{-1} gave higher totatl yield per square meter (10.73 and 11.20)kg.m^{-2} respectively.

Regarding the double interaction the interaction between Ravilo and(18ml.L^{-1}) of humic acid give higher yield in square meter(18.67)kg.m^{2} compared with other interaction specially with untreated treatments specially the interaction between humic acid and Fabyoula that give lower total yield (6.98)kg.m

Table (11): Effect of, humic acid, and their interactions on totalyield.

Cultivars	Humic acid			Effect
	0	9g.L^{-1}	18g.L^{-1}	of cv.
Sifra	8.00b	16.27ab	8.27ab	10.84ab
Ravilo	9.08ab	11.20ab	18.67a	12.98a
Silvana	9.07b	5.87b	8.00ab	7.64c
Fabyoula	6.93b	9.60ab	9.87ab	8.80ab
Effect	8.27c	10.73ab	11.20a	
of Humic				

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

Discussion:

Vegetative growth

It is observed from the above mentioned results in Tables (2,3,4,and5) that an significant increase occurred in, branches number, leaves number, leaves area, and total chlorophyll content S.P.A.D., Increasing vegetative components by the humic acid may be attributed to the role of humic acid on improving the soil fertility and increasing the availability of nutrient elements and consequently increased plant growth . The plant growth characters may give the clear indicators on the size and dense of vegetative growth of cucumber plants, and this may refer to the number of flowers and quantity of fruits that can then produced from it(7),or they may be due to the role of humic acid that provides nutrient elements that share in bio efficiency and then increasing the growth(1).

David *et. al*.(11) have reported that humic substances promoted growth and more mineral nutrient uptake of plant due to the better-developed root systems. Moreover the enhancement of the plant growth using potassium humate had been reported to be due to increasing nutrients uptake such as N, Ca, P, K, Fe, (5). Nardi*et. al*.(22) mentioned that humic acid had a gibberellins and auxin exhibiting higher amounts of phenolic compounds and considerable amount of acids. The increase in the vegetative growth could be attribute to the ability of humic acid to improve the chemical, physical, and biological properties of the soil, and its decomposition results in the formation of carbonic acid which contributes to soil (pH) change and assists in dissolving some insoluble minerals that are unavailable for plants especially Phosphorus, Potassium, Magnesium and Calcium and increases the availability of micronutrients, so they are readily absorbed by the plant leading to increasing the photosynthesis process. Furthermore, the organic complexes are formed with the micronutrients Zn, Fe, Cu which enhance their availability and thus support the plant growth and development(21).

Effect of Humic Acid Qualitative and Yield Characters of Potato Varieties.

It is indicated from the Tables (6,7,8,9,10 and 11) that the application of organic matter and their effects on yield and its components could be through their enhancing effect on increasing soil moisture holding capacity, improving soil texture as well as promoting the uptake of nutrients leading to stimulation of plant growth (Table 4) and consequently on total yield and its components(35).Rotenberg *et. al*.(26) reported that Additions of organic amendments (composts) to agricultural soils can lead to improved soil quality and reduced severity of crop diseases as well as increased cucumber yield. It was stated that the coal –humic

fertilizers activated the biochemical processes in plants (respiration, photosynthesis and chlorophyll content (Table 3) and increased the quality and yield of potatoes (2).Lobartini*et. al*.(18) stated that the ameliorative effects of humic acid on the plant yield might have come from the effect of humic acid on the adsorption of water and the physical structure of soil by the drainage and aeration and the absorption of plant nutrient by the positively affected plant roots by humic acid and the metabolism of plant nutrients absorbed by the plants(6). The improvement of fruit quality may be attributed to better growth of plant at different rate of humic acid The organic fertilizers are considered the conceder source of macro and microelements that are necessary for plant growth and proved the soil with humus that enhance the physical characters of soil and their ability to absorption water and restored it, also its reduce the loss of nutrient elements and increase the activity of microorganisms, and gave high yield with good qualities (15). Improving yield could be related to the increasing of soil aggregates due to the high content of the organic matter in humic substances application. It is believed that humic acid being a poly functional molecule (34) attracts micronutrients cations, preventing them from leaching and releasing them slowly to the plants (12).

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استجابة بعض أصناف البطاطا (*Solanumtuberosum*L.) لتراكيز مختلفة من حامض الهيوميك

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المستخلص

أجريت هذه الدراسة خلال الموسم الزراعي 2016-2017 في كلية الزراعة جامعة دهوك/ اقليم كوردستان/العراق لدراسة تأثير رش حامض الهيوميك بثلاثة تراكيز هي (0، 9 و 18)مل. لتر$^{-1}$ لأربعة أصناف من البطاطا (*Solanumtuberosum*L.)(Sifra, Ravila, Silvana and Fabyoula)، والتي زرعت تحت ظروف البيت البلاستيكي. وتبنيت من النتائج ان كل الأصناف كانت جيدة في نموها الخضري والصفات النوعية والإنتاجية وخاصة صنف (Ravila) والذي أعطى أعلى أنتاج في المتر المربع مقارنة بالأصناف الأخرى. كذلك فان رش النبات بتركيز 18مل .لتر$^{-1}$ من حامض الهيوميك أعطى أفضل النتائج للصنف (Ravila)، مقارنة مع النباتات الغير مرشوشة بحامض الهيوميك والتي اعطت اقل أنتاج واقل عدد للدرنات للنبات.

كلمات مفتاحيه: أصناف. بطاطا. حامض الهيومك.

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