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THE ROLE OF SOME HUMIC ACID PRODUCTS IN REDUCING OF USE MINERAL FERTILIZERS AND IMPROVING SOIL PROPERTIES AND NUTRIENT UPTAKE

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ABSTRACT

A field experiment was carried out during winter season of 2009-2010 firstly to evaluate the effect of some commercial products of humic acid in reducing mineral fertilizer rates, improving some soil properties (bulk density, total porosity, available water, mean weight diameter and soluble ions), plant growth and nutrients uptake by broad bean plant. secondly is trying to reduce the mineral fertilizer application for their dangerous on general health and highly cost of these fertilizer, with improving production of important crops by natural material. The commercial compounds (Leq humus, Hammer, Wesko plus K, K-Promote and Commander) were added to soil by a rate 10 kg fed^{-1} plus half the general recommendation.

The results could be summarized as follows:

-The values of soil bulk density decreased as a result of application humic products as compared with the control (mineral fertilization only).

-Soil total porosity and values of available water increased due to the treatments used.

-The values of mean weight diameter and soluble ions increased due to the treatments.

-The values of soil organic matter and available micronutrients increased due to the treatments.

-The plant dry matter yield values (straw and seeds) increased with of humic treatments application

-The treatments under investigation gave higher percentage values of macro and micronutrients (content and uptake) in straw of broad bean plants as compared to the control.

Keywords: Humic acid, plant growth and nutrients uptake

INTRODUCTION

Humic acid is one of the most important components of Bio-Liquid Complex, because of its molecular structure; it provides numerous benefits to crop production. It helps break up clay and compacted soils, assists in transferring micronutrients from the soil to the plant, enhances water retention, increases seed germination rates, penetration, and stimulates development of micro flora populations in soils. Humic acid is not a fertilizer, but instead a compliment to fertilizer. Ali et al (2006) studied the role of humic acid in reducing mineral fertilizer rates applied in Vineyards. They found that the application of humic acid with mineral N and K sources were effective in increasing bud burst, fruitful buds, leaf area, NPK percentages in the leaves, total leaf chlorophyll content, number of clusters/vine, cluster weight/vine, yield/vine and improved physical and chemical properties of soil as compared to using mineral N and K alone for flame seedless and superior Seedless grapevines. Humic acid is a commercial product contains many elements which improve the soil fertility and increasing the availability of nutrient elements and consequently affected plant growth and yield. Humic acid particularly is used to remove or decrease the negative effects of chemical fertilizers and some chemicals from the soil, (Ali *et al.*, 2009).

Hartwigson and Evans (2000) stated that the humic substance supply growing plants with food makes soil more fertile and productive, increases the water holding capacity of soil; therefore, it helps plants resist droughts and stimulates seed germination. Humic acid reduces other fertilizer requirements, increases yield in crops, improved drainage, increases soil aeration, increase the protein and mineral contents of most crops and establish a desirable environment for microorganism development. Salman et al (2005) studied that, the fruit yield and quality of watermelon as affected by hybrids and humic acid application, and found that the application of humic acid up to 6 L/fed^{-1} increased total yield of all hybrids and NPK content in leaves of plant.

Recent studies on the subject summarize the effects of humic substances on plant growth and mineral nutrition, underlining, above all positive effects on seed germination, seedling growth, root initiation, root growth, shoot development and the uptake of some macro (e.g. K, Ca, P) and microelements (e. g. Fe, Zn, Mn) (Chen and Aviad, 1990; Nardi, *et al.,* 2002; Varanini and Pinton, 1995; Bohme and Lua, 1997; Eyheraguibel, *et al.,* 2008).Also Selim et al (2009) and Selim *et al.* (2009) studied the beneficial effects of humic substances fertigation on soil fertility to potato grown on sandy soil; who stated that the application of humic acid combined NPK fertilizers of fertigation significantly increased the tuber yields, tuber quality indicators, NPK nutrient concentrations in potato tissues and fertilizer use efficiency (kg yield kg NPK fertilizer); and he added, with previous treatments resulted in lesser leaching N, K to deeper layer, higher available P to deeper layer of soil and increased soil fertility as compared with NPK fertilizer alone.

The objective of this study was to evaluate the effect of some commercial products of humic acid in reducing of mineral fertilizer rates, improving some soil properties, plant growth and nutrients uptake by broad bean plants.

MATERIALS AND METHODS

A field experiment was carried out to evaluate the effect of five commercial products of humic acid (Leq humus, Hammer, Wesko plus K, K-Promote and Commander) in reducing mineral fertilizer rates, improving some soil properties (bulk density, total porosity, available water, mean weight diameter and soluble ions), plant growth and nutrients uptake by broad bean plant.

The experiment was conducted during winter season of 2009-2010 at the Experimental Farm of Al-Azhar University, Nasr City, Cairo Governorate. The soil sample (0-30 depth) was routinely analyzed according to Klute, 1986 for physical properties; and chemical properties of the soil (i.e. EC, pH, organic matter and soluble ions according to Page *et al.*, 1982) to detect the changes that might take place in soil characteristics. The results are presented in Tables 1 and 2.

Individual plots 1.5 m × 1.5 m were arranged in a randomized complete block design consisting of five humic acids commercial products (HA) with three replicates. Broad bean plant (*Vicia faba L*) was sown in the first week of November. The treatments were as follows: the control was fertilized by the general recommendation of Agricultural Ministry (N P K); while the other treatments were by application of 10 kg fed^{-1}(about 7 g $plot^{-1}$) commercial products of humic acid plus half the general recommendation. The treatments included:

1- Control- the general recommendation without humic products addition.
2- HA_1- Leq Humus, containing 87 % humic acid and 8.4% potassium.
3- HA_2- Hammer, containing 86 % humic acid and 9.3% potassium.
4- HA_3- Wesko plus K, containing 60 % humic acid and 9.6% potassium.
5- HA_4- K-Promote, containing 85 % humic acid and 4.8% potassium.
6- HA_5- Commander, containing 75 % humic acid and 11.4% potassium.

Table 1. Some physical and chemical properties of the investigated soil sample.

Particle size distribution %				Soluble ions in 1:2.5 soil water extract (meq /100g).								pH	OM %	EC $dS\ m^{-1}$	$CaCO_3$ %
Sand	Silt	Clay	Texture	Ca^{++}	Mg^{++}	K^+	Na^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$				
76.09	13.32	10.59	S.loam	1.35	0.28	0.33	1.42	0.0	1.87	1.33	0.18	7.54	0.91	0.34	2.32

Table 2. Some nutrients content in the investigated soil sample.

Macro-nutrients			Micro-nutrients							
Total(meq/100g)			Total (mg/kg)				Available(mg/kg)			
N	P	K	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
1.11	0.21	8.68	1887	768	1052	104	5.09	3.91	4.18	0.83

In the end of the experiment the harvested plants were digested to determine NPK and micronutrients; Fe, Mn, Zn and Cu according to Page *et al.* (1982).

RESULTS AND DISCUSSION

a. Effect of humic products treatments on some soil physical properties.

Data in Table 3 show the important soil physical properties as affected by the application of humic products. The data reveal that soil bulk density, total porosity, moisture content%, available water % and mean weight diameter were improved due to the used of humic products. Concerning the effect of treatment on soil bulk density, the values were 1.35

Mg m^{-3} at the control (mineral fertilization only) and decreased to 1.23 Mg m^{-3} with HA_1 treatment, as compared with the other treatments.

On contrary, the values of total porosities were increased due to the aforementioned treatments; the highest values obtained with HA_1, HA_3 and HA_4,. While the lowest values i.e. 51.9 and obtained with HA_2 and HA_5 as compared with the control).

Table 3. Some soil physical properties as affected by humic products treatments.

Treatment	Bulk density Mg m^{-3}	Total porosity %	Moisture content % at		Available water %	Mean weight diameter Mm
			0.33 bar	15 bar		
Control	1.35	48.1	17.5	9.5	8.0	0.315
HA_1	1.23	52.7	19.3	9.9	9.4	0.375
HA_2	1.25	51.9	18.7	9.8	8.9	0.370
HA_3	1.24	52.3	19.5	10.2	9.3	0.375
HA_4	1.24	52.3	19.5	10.2	9.1	0.365
HA_5	1.25	51.9	18.5	9.8	8.7	0.362

Also, data in the same Table reveal that, the increasing values of soil moisture content % (0.33 and 15 bar) improved available water % due to the used of humic products; the lowest values of soil moisture content and available water % were obtained at the control and increased with HA treated. With regard to the effect of humic acid products application on mean weight diameter mm data revealed that the some trend of the available water % was observed for mean weight diameter mm. These results are in harmony with Barzegar *et al.* (2002) and Zeleke *et al.* (2004); who stated that the application of humic products to soil is known to significantly affect the surface soil chemical (nutrient recycling) and especially physical characteristics. These include aggregate stability, lower bulk density, less soil compaction, higher soil porosity and this increased available water.

b. Effect of humic products treatments on some chemical soil properties.

Data in Table 4 show that some soil chemical properties were affected by the applied humic products, where the values of pH, EC, soluble ions and organic matter increased with application humic products. The lowest values of this parameter were obtained at the control and increased due to humic products treatments. This improving in soluble ions with humic acid may be due to the role of humic substances is mainly related to the enrichment of nutrients uptake where these humic substances increases soil's cation exchange capacity (ability to hold and release cations such as K^+, Ca_2^+, or NH^+), and can also form aqueous complexes with micronutrients (Aiken *et al.,* 1985).

Table 4. some soil chemical properties as affected by humic products treatments.

Treatments	pH	EC. ds m^{-1}	Soluble ions in 1:2.5 soil water extract (meq /l).							
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
Control	7.59	0.36	1.37	0.34	1.51	0.37	0.0	1.90	1.44	0.25
HA_1	7.61	0.38	1.37	0.32	1.77	0.38	0.0	1.92	1.51	0.41
HA_2	7.62	0.42	1.37	0.38	1.98	0.39	0.0	1.95	1.63	0.54
HA_3	7.64	0.46	1.41	0.40	2.35	0.41	0.0	2.00	1.73	0.84
HA_4	7.67	0.49	1.45	0.42	2.43	0.56	0.0	2.11	1.79	0.96
HA_5	7.67	0.49	1.46	0.45	2.44	0.56	0.0	2.13	1.80	0.98

These results are in harmony with Mikkelsen (2005) who stated that humic materials are able to complex various cations and serve as a sink for polyvalent cations in the soil. They have a negative surface charge at all pH values where crop growth occurs. Organic substances have been demonstrated to enhance the solubility of soil ions through the complexation of Fe and Al in acid soils and Ca in calcareous soils. One of the most striking characteristics of humic acids in soils and other environments is their ability to interact with metal ions and soil minerals to form complexes of varying properties and increasing chemical stability**.**

Concerning the effect of humic acid products application on organic matter and available of micro-nutrients**,** data in Table 5 reveal that the values of organic matter and available of micro-nutrients were affected due to the application of humic acid products as compared with the untreated control; the highest values of organic matter recorded with HA_2 and HA_3 as compared with the lowest values were obtained with the other treatments and control.

Table 5. Organic matter and available of micronutrients as affected by humic products treatments.

Treatments	O.M.	Micro-nutrients			
		Available(mg/kg)			
	%	Fe	Mn	Zn	Cu
Control	0.93	5.42	4.58	5.32	1.21
HA_1	0.95	7.28	8.91	7.23	1.75
HA_2	0.96	6.79	8.00	7.17	2.16
HA_3	0.96	5.52	8.02	7.18	2.15
HA_4	0.95	6.54	7.82	5.99	1.82
HA_5	0.94	6.63	6.32	7.03	1.84

Also, the highest values of available micronutrients were recorded with HA_1treatments for Fe, Mn and Zn; and HA_2 for Cu. While the lowest values of available micronutrients were obtained at the control. In this concern, Gulshan and Singh (2006) stated that the additional of humic substances improved soil physical and biological properties, which are reflected generally, on soil fertility status; and the combined application of chemical fertilizers and humic substances could be an effective method to increase the plant availability of nutrients in soils.

c. Effect of humic products treatments on dry matter yield, nutrients content and uptake.

Data presented in Table 6 show that the dry matter yields of straw and seeds were affected by the application of humic acid at all treatments; and the highest values of straw and seeds dry matter yield were recorded with HA_1 followed HA_2 as compared with the other treatments and control. While the lowest values for straw recorded with HA_5, and for seeds with at HA_3 as compared with the control.This improving of dry matter yield of straw and seeds of broad bean plants with humic acid may be due to that the role of humic acid in improve the plant growth. These results are in agreement with those of Ayuso *et al.*, (1996) who stated that the humic substances affected on the plant by changing the soil structure, increase cation exchange capacity, stimulate microbial activity and has the capacity to solubilize or complex certain soil ions; and El-Bassiony *et al.* (2010); who studied the response of snap bean plants to mineral fertilizers and humic acid application, and found that the vegetative growth of snap bean plants, green pod yields and its quality were improved by increasing the levels of humic acid spraying; also the highest values of vegetative growth parameters were recorded with plants received NPK fertilizers at 100 % of the recommended dose with spraying by humic acid at 2 g/l, followed by those received NPK-fertilizers at 65% and 35% of the recommended dose with spraying by humic acid at 2 g/l level.

Table 6. Effect of humic products treatments on dry matter yield and values of macronutrients content (%) and uptake (mg/plant).

Treatments	D.M. Y. g/plant		Nitrogen		Phosphorus		Potassium	
	straw	seeds	Content	Uptake	Content	Uptake	Content	Uptake
Control	19.45	6.58	3.91	380.24	0.32	31.12	3.81	370.52
HA1	24.12	14.99	4.37	527.02	0.38	45.82	3.94	475.16
HA2	24.00	13.85	4.21	505.20	0.39	46.80	4.02	482.40
HA3	20.41	6.94	4.32	440.85	0.43	43.88	3.98	406.15
HA4	20.58	7.06	4.34	446.58	0.32	32.92	4.11	422.91
HA5	20.14	7.59	4.46	441.12	0.34	34.23	4.08	410.85

Concerning the effect of humic acid products application on macronutrients content and uptake by broad bean plant, the data presented in Table 6 show that the values of NPK content and uptake were affected due to the application of humic acid products as compared with the untreated control. The highest values of nitrogen content and uptake obtained with HA_5 and HA_1 treatments,; and for phosphorous with HA_3 and HA_2 treatments, .While the highest values for potassium obtained with HA_4 and HA_2, as compared with the lowest values with the untreated control. These increases in macronutrients content and uptake by broad bean plants with humic acid might be due to the role of humic acid in improving of soil fertility and increasing the availability of these nutrients. In this concern, Selim *et al.*, (2009) found that application of humic substances through drip irrigation enhanced tubers yield quantity, starch content and total soluble solids and this application associated with the decrease of nutrients leaching, as a result of increasing macro-and micronutrients concentration in potato tubers, as well as increasing concentration of these nutrients in soil after tubers harvesting. These results are in harmony with Celik *et al.* (2008) who stated that the soil application of humus at 1 and 2 g kg^{-1} dose had appositive effect on dry weight, N, P, K uptake of maize plant**.** Also, Erdal *et al.*, (2000) determined the dry weight, P concentration, P uptake and residual available P amount of maize plant high in humic acid applications, and that the effect of humic acid on the above parameters combined with P fertilization was higher than that of humic acid alone.

With regard to the effect of humic acid products application on micronutrients content and uptake by broad bean plant, the data presented in Table 7 show that the values of Fe, Zn, Mn and Cu content and uptake were affected due to the application of humic acid products as compared with the untreated control.

Table 7. Effect of humic products treatments on micronutrients content ($mgkg^{-1}$) and uptake (µg/plant).

Treatments	Fe		Zn		Mn		Cu	
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake
Control	452	4395	47.12	458	49.15	477	22.71	220
HA1	472	5692	52.19	629	63.71	768	29.93	360
HA2	468	5616	59.02	708	62.51	750	33.20	398
HA3	473	4826	60.41	616	61.41	626	28.18	287
HA4	467	4805	59.31	610	59.20	609	27.45	282
HA5	456	4591	49.80	501	56.48	568	30.18	303

The values of Fe content and uptake were 452 mg kg^{-1} and 4395 µg/plant at the untreated control and increased to 472 mg $kg^{-1}$and 5692 µg/plant obtained with HA_1, respectively. While the lowest values of Fe content and uptake were 456 mg kg^{-1} and 4591 µg/plant with HA_5 treatments, respectively. Concerning the zinc content and uptake data in the same table revealed that the highest values for zinc content obtained with HA_3 treatment; and 708 µg/plant for zinc uptake obtained with the HA_2 treatments as compared with the lowest values of the untreated control. Also, the magnesium content and uptake data in this table revealed that the mentioned trend of Fe was observed for Mg. On the other hand, the highest value of Cu content and uptake were recorded at HA_2 and decreased with other treatments of humic products. This increase in micronutrients content and uptake due to the application of humic products may be attributed mainly to the beneficial roles of HA components. The first, humic acid about (60 to 86 %), which combine with sunlight and photosynthesis to produce metabolic energy, then include the biochemical manufacture of complex organic material, especially carbohydrates from CO_2, water, nutrients, and inorganic salts, along with sunlight energy for chlorophyll production. The second is the role of potassium (4.8 to 11.4 %) in plant growth and nutrition, which plays a significant role in carbohydrate metabolism and translocation in plant. On the other hand, increase in uptake of macro and microelements influenced by humic substances have been reported in a large number of publications and in different plant species. In addition, it was stated that the coal-humic fertilizers activated the biochemical processes in plants (respiration, photosynthesis and chlorophyll content) and increased the quality and yield of potatoes. Furthermore, the growth promoting activity of humic substances was found to be caused by plant hormone-like material contained in the humic substances. Jones *et al.* (2007) found that the presence of auxin type reactions by humic substances that result in increased growth. This can explain the increment of yield in response to humic acid application. Furthermore, the addition of humic products to a hydroponic solution stimulated both root and shoot development, resulting in an increase of 87 % in corn yield . More recently, it was reported that humic acid contain cytokinins and their application resulted in increased endogenous cytokinin and auxin levels which possibly leading to improve growth of bent grass under draught conditions,(Zhang *et al.*, 2003; and Zhang and Ervin, 2004).

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دور بعض منتجات حمض الهيوميك فى خفض استعمال الاسمدة المعدنية وتحسين خواص التربة وامتصاص المغذيات

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أقيمت تجربة حقلية خلال شتاء موسم 2010/2009 لتقييم دور بعض منتجات حمض الهيوميك التجاريه فى خفض استعمال الاسمده المعدنيه وتحسين خواص التربه(الكثافه الظاهريه،المساميه الكليه،الماء الميسر،متوسط القطر الموزون والايونات الذائبه) كذلك على نمو النبات وامتصاص المغذيات النباتيه. ويعتبر هذا البحث محاولة لتقليل وترشيد استخدام الأسمدة المعدنية نظرا لخطورتها على الصحة العامة وارتفاع تكلفة استخدامها مع الحفاظ على انتاجيه المحاصيل الهامه تحت ظروفنا المحليه عن طريق أستخدام مثل هذه المواد الطبيعية. وقد تم اضافة هذه المركبات (ليك هيوماس , همر , فسكوبلس K , K برموت و كوماندور) بمعدل 10 كجم / فدان مع نصف التوصية السمادية مقارنة بالكنترول (التوصية السمادية الكاملة بدون اضافة هذه المركبات)

ويمكن تلخيص أهم النتائج التى أمكن الحصول عليها فيما يلى:.

- انخفضت قيم الكثافة الظاهرية للتربة كنتيجة لاضافة منتجات حمض الهيوميك مقارنة بالكنترول(تسميد معدنى فقط).
- زادت قيم المسامية الكلية للتربة وحدث تحسن ملحوظ فى المحتوى الرطوبى للتربه وكذلك الماء الميسر.
- زادت قيم المتوسط الموزون للتجمعات وزادت أيضا قيم المادة العضوية للتربة والايونات الذائبه .
- زادت قيم الماده العضويه وكذلك الكميه الميسرة من العناصر الصغرى (الحديد، الزنك، المنجنيز والنحاس).
- زاد انتاج المادة الجافه بالنسبه للقش والبذورمقارنة بالكنترول.
- أعطت المعاملات تحت الدراسة أعلى القيم لمحتوى قش النبات من العناصرالكبرى والصغرى.
-عموما يمكن القول أن استخدام منتجات حمض الهيومك لها أثر ملحوظ فى تحسين الخواص الارضيه (الطبيعيه والكيميائيه) وكذلك نمو النبات وانتاجة ومن ناحية أخرى تقلل من التلوث عن طريق تقليل استخدام الاسمدة المعدنيه.

قام بتحكيم البحث

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