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INFLUENCE OF THE EXTRACTED HUMIC SUBSTANCES FROM FARMYARD MANURE ON ROOTING AND VEGETATIVE GROWTH OF *Ficus Benjamina* L. AND *Geranium sanguineum* L PLANTS.

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ABSTRACT

The present study was conducted in the experimental farm of Agricultural Development System Project in Giza, during the growing seasons 2002|2003 and 2003|2004, using humic substances extraction from farmyard manure (HAs) to study their effect on soil nutrient and growth of *Ficus benjamina* L. and *Geranium sanguineum* L. plants. The humic acid was extracted with KOH and HNO_3 and characterized by chemical methods and UV, visible absorption and infrared spectroscopic analysis. The humification index, humification ratio, and humic acid% values were 0.70, 0.42 and 39.3, respectively. The elemental composition of humic acid was as following: C 44 %, N 4.73 %, H 4.21 %, S 1.52%, O 45.54% and C:N 9.30. The absorbance decreased as wavelength increases and no absorption found in range of 300-700 nm while a small absorption peak appeared at wavelength near 270 nm. The E_4/E_6 ratio of cleared humic acid was 5.11. Sandy and loamy sand soils were treated with HAs (6 g L^{-1} at pH5) at field capacity, nitrogen, phosphorus, zinc, copper, manganese and iron concentrations increased as compared with untreated soil. The effect was more pronounced in sandy than the loamy sand soil. The foliar application treatments of extracted HAs at pH 5 (2, 4 and 6 ml of HAs $100ml^{-1}$.) with 0.1N KOH and 0.1N HNO_3 from farmyard manure has significant improved the root mass, root length, roots number, leaf area, plant height, number of branches $plant^{-1}$ of *Ficus benjamina* L. and *Geranium sanguineum* L. and nutrient content of *Ficus benjamina*.

INTRODUCTION

It has been recognized for centuries that the soil containing ample organic matter are typically more productive than those of without it. Composts of organic fertilizers from farmyard manure and agricultural wastes contain a substantial amount of organic matter, with a significant amount of humic substances (Deiana, *et al.*, 1990). Humic substances contain a variety of functional groups, including CooH, phenolic OH, enolic OH, alcoholic OH, quinone, hydroxyl quinone, lactone and ether (Sposito, 1986). However, many investigators showed that humic substances isolated from different materials contained 45-65% carbon, 30-48% oxygen, 2-6% nitrogen, and about 5% hydrogen Humic substances (HS) are an extremely important soil component because they constitute a stable fraction of carbon (C), thus regulating the carbon cycle and the release of nutrients, including nitrogen (N), phosphorus (P), and sulphur (S). Additionally, the presence of HS improves water-holding capacity, pH buffering and thermal insulation (Stevenson, 1994). Most soil scientists and agronomists recognize humic substances as the most important component of a healthy fertile soil (Pettit, 2002). In arid and semi-arid regions, the low content of organic matter in the soil due to absence of plant covers and also, indeed higher pH value over 7 and lime content depresses the availability of macro and micronutrient of the soil to plants. Recently, it has been focued on evaluating the effect of humic substances extracted by NaOH and HCL, while the effect of humic acid extracted with KOH and HNO_3 on the plant growth has not been studied yet. Useing KOH and HNO_3 will enriches the humic substances with potassium and nitrogen as compared with the other extractions (NaOH and HCL). The aqueous base solutions for humic substances extraction was first described by Achard (1986) who used potassium hydroxide, which was considered an important solution for most workers since (Hayes, 1985).

Kononova and Pankova (1966) compared the root development of corn growing in solution culture with or without added humic acid found that root length and number doubled in response to humate added at 4- 5 mg l^{-1}. Dixit and Kishore (1967) reported enhanced germination in corn (*Zea mays* L.), barely (*Hordeum vulgare* L.), wheat (*Triticum sativum* L.) treated with humic or fulvic acids. Lee and Bartlett (1976), also working with corn grown in solution culture, found that rooting was enhanced significantly at humate concentration of 8 mg L^{-1}.

Humic acid produced by extracting an organic matter source with acidic solution (pH = 2) any fraction insoluble below pH 2 or soluble above is considered a humic acid (Aiken *et al.*, 1985). Vaughan and Malcolm (1985) compared root and shoot growth of wheat grain in water alone, a complete (Hoagland's) nutrient solution, and each solution supplemented with 50 mg/ L humic acid. Their experiments showed a 58% increase in root growth when humic acid was added to water alone. Addition of humic acid to plants growing in nutrient solution increased root growth approximately 25% compared with plants growing in nutrient solution alone. The positive effect of humic substances on growth of numerous plants in the *Gramineae* family has been well documented (Chen and Aviad, 1990).

Guar (1964) found increased N, P, and K uptake in perennial ryegrass (*Lolium perenne* L.) grown in sand amended with humic acid extracted from compost. Dormaar (1975) reported increase in nitrogen (N) uptake by rough fescue (*Festuca scabrel* Torr.) in response to application of humic substances extracted from three soils while phosphoruse (P), potassium (K), calcium (Ca), magnesium (Mg), and sodium (Na) uptake were unaffected. In a review of research evaluating humic substances, Chen and Aviad (1990) studiesd the influence of humic materials on the nutrient concentration in the soil and their uptake by plants. They found that no increase in N uptake of bermudagrass (*Cynodon dactylon* L.) following application of a commercial humate material at 0, 268, and 803 kg ha^{-1}. Whether nutrient uptake increases, decreases, or remains constant in response to humic substances appears to depend in large part on the plant species and humic materials evaluated.

Recently (HA) was extracted with NaOH and HCl have been promoted for use on some plants. While the effect of humic substances extracted with KOH and HNO_3 on other numerous plants, which have been document. The chemical analytical and spectroscopic characterization of humic acid (HA) extracted from compost of farmyard manure with KOH and HNO_3 was tested in this work to determine the potential of humic substances to affect soil nutrients as well as root and vegetative growth of *Ficus benjamina* L. and *Geranium sanguineum* L., and the nutrients concentration of Benjamin plant. *Ficus benjamina* L. belongs to the family *Moracea*. It's the most popular evergreen outdoor or indoor plants as well as street trees. It's also used for medical properties and industrial manure uses. While, *Geranium sanguineum* L. (bloody granesbill) belongs to the family *Geraniaceae*. Which have dense clump forming herbaceous perennial with spreading rhizomes, drought tolerant and a splendid ground cover (Brickil, 1996).

MATERIALS AND METHODS

Humus composition and characteristic:

The compost was purchased from organic fertilizer company in Egypt to perform the experiment. The humic acid was extracted from the compost and purified according to the method of Aiken (1985) with some modification by using the KOH and HNO_3 instead NaOH and HCL.

The humification index {humic acid (HA)/fulvic acid (FA)}, humification ratio (HA/FA+NHS) and humic acid % of compost were determined according to the methods reported by Sugahara and Inoko (1981).

The C, H, N, O, and S contents of the dried (HA) sample was obtained with Samatcho CHN-O-rapid elemental analyzer. Fourier transform infrared (FTIR) spectra of the dried HA sample was obtained from KBr discs (each disc contained 1 mg sample and 300 mg KBr). The spectra were recorded in the range from 400 to 4000 cm^{-1} on a Samatcho FTS-7 Fourier transform infrared spectrophotometer. UV/VIS spectra of HAs (4 mg) dissolved in 100 mL using wavelengths ranging from 300 to 700 nm.

Effect of humic substances on mineral content of the soil:

Sandy and loamy sand soils were treated with humic solution in order to study the effect of humic substances on P, K, Cu, Zn, Mn and Fe concentrations of the soil as compared with untreated soil. The level of humic substances addition was selected according to normal application rates (6 g L^{-1}) used in agriculture (Ram and Verloo, 1985). The density of HAs was 0.045 g mL^{-1}. Sand and loamy sand soil samples were incubated at field capacity moisture for three weeks, for appropriate equilibrium and then air-dried. The pH of soil water suspension ranged from 3.5-6.5. The amounts of the minerals under study in the soil sample were determined according to the procedures of Page (1982).

Effect of humic substances on *Ficus benjamina* L and *Geranium sanguineum* L.:

The present study was conducted in the experimental farm of Agricultural Development System Project during the growing seasons 2002/2003 and 2003/2004.

A mixture of sandy soil and peat moss at the rate of 1:2 v/v, were mixed thoroughly and placed in plastic pots (25cm diameter) in the greenhouse. Four unrooted cuttings obtained from one-year-old semi-hard wood cuttings from *Ficus benjamina* L. and other four terminal cuttings from *Geranium sanguineum* L. in the beginning of March were transplanted to each pot. Four treatments (0, 2, 4 and 6 mL 100mL^{-1} pot^{-1} of humic substances) were applied and six replicates were used for each treatment. Pots were watered twice a day with tap water. The experiment was distributed in complete randomized design. After growing for 90 days, plants were cautiously removed from the soil to determine plant height, number of branches|plant, leaf area, number of roots, root length and root fresh weight. Investigate the effect of HAs on nutrient concentration, about 0.5g of dried plant tissues were used for N, P, K, Fe, Mn, Zn and Cu determination (piper, 1947). Data were subjected to statistical analysis as means of the two seasons using the least significant difference (LSD) according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Humus composition and characteristic

The humus composition is listed in Table 1.Humification index, Humification ratio and Humic acid % were 0.70, 0.42 and 41.2%, respectively. Humification index was used as an indicator of humus quality and this ratio represents an important characteristic of compost as an agronomic indicator for the crop production (Candellas *et al.*, 2002). In general, fresh composts contain low levels of humic acid (HA) and higher levels of fulvic acid (FA) and thus the humification ratio and humic acid % are less than 1 and 50%, respectively. Sugahara and Inoko (1981) found that the humic acid % ranged between 6 to 95 % in refuse compost of different cities in Japan and they concluded that the humic acid % depends on the type of compost.

The chemical composition of the humic acid isolated from compost in (Table 1), showed that C, N, H, S, and O contents were 44, 4.73, 4.21, 1.52 and 45.54 %. These values are within the range for HA of soil origin (C 37.18-64.10, N 0.50-7.00, H 1.64-8.00, S 0.1-4.88 and O 27.1-51.98 %) according to the statistical evaluation of elemental composition of 215 soil HA samples (Rice and MacCarthy, 1991). According to the above results, it might be concluded that the method of HA extraction with KOH and HNO_3 has no effect on the elemental composition of humic acid. The high value of hydrogen indicated that the HA is aromatic nature, where Ayso *et al.* (1997) indicated that the composting process aromatics the HA.

The data indicated that the H/C atomic ratio was (0.096) below than 1.3, this means that humic substance is not affected by the method of extraction, while the Steelink (1985) suggested that H/C ratio lies above 1.3 might be indicative of non-humic substances. The magnitude of the H/C ratio has been used to indicate the degree of aromacity (i.e unsaturation) or aliphacity of a substance.

The chemical condensation was also detected by calculating the ratio of optical densities at 465/665 mn (E_4/E_6) taking into consideration that this ratio decreases with the increase in the condensation degree of humic acid (Kononova, 1966). It was found that E_4/E_6 ratio for HA was 5.11 (Table 1). This result agreed with the findins of Gomah *et al.* (1978). They found that the E_4/E_6 ratio of HA from different sources of manure and plant materials ranged between 5.1 and 6 with an average of 5.5.

Table (1): Humification index, humification ratio, E_4/E_6 ratio, C/N ratio, humic acid% and element composition of HAs extracted from compost with KOH and HNO_3

Humificaton index	Humification ratio	E_4/E_6 ratio	C/N ratio	Humic acid %	Element %				
					C	N	H	S	O
0.70	0.42	5.11	9.30	41.2	44	4.73	4.21	1.52	45.54

The absorption in the UV region is mainly caused by the excitation of electron ion pair, usually oxygen and conjugated C=C double bonds. Ion pair electrons and charge-transfer system cause the absorption in VIS region. Figure (1) shows that the absorbance decreased with increasing the wavelength but the absorbance in UV range was higher than in visible absorption. Sugahara and Inoko (1981) attributed the increase in UV absorption of the humic acid is probably to an increase in Л electrone, e.g. unsaturated and/or aromatic compounds. The result of Fig (1) reveals that the shape of the absorbance had not been affected with the method of extraction.

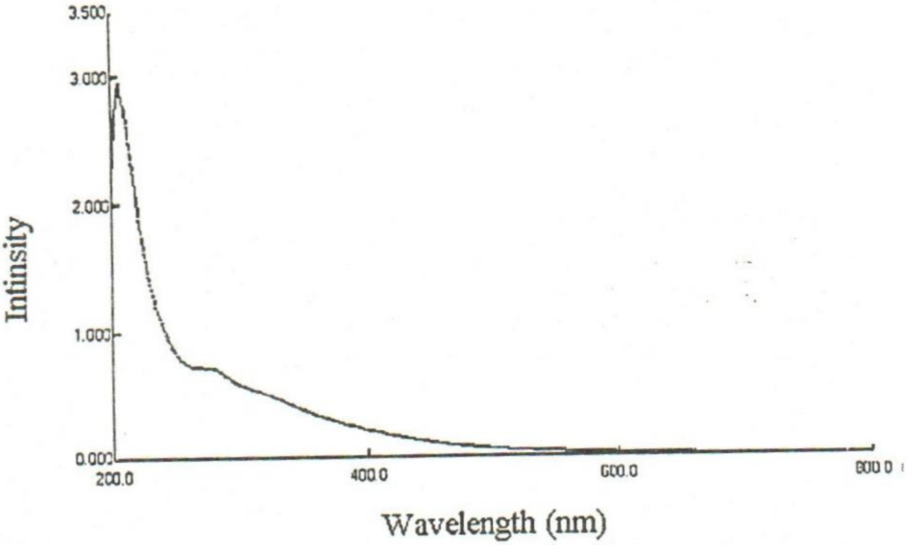

Fig. (1): Absorption spectra of humic acid obtained from farmyard manure compose with OH and HNO_3.

The information from spectroscopic techniques (Fig. 2) is suporting the results that of the chemical analysis and shows that the method of extraction has no effect on absorption bands. However, the FTIR spectra of humic acid extracted in this study resembled those of soil Has. In FTIR spectra of HA there are peaks caused by aliphatic compounds (2930-2850 and 1450 cm^{-1}) where the result of chemical analysis confirm that, where the H/C atomic ratio is 1.15. The band at 1031 cm^{-1} is an indicator to carbohydrates. The high nitrogen value (4.73%), which is produced from using the nitric acid in the HA extraction lead to the presence of amides and peptides bands at 1650 and 1540 cm^{-1}. Where Gonzalez-Vila and Martin (1987) attributed the signiles in the 1680-1650 and 1560-1530 cm^{-1} zones to amides and peptides. Also the bands at 1650 could indicate either-CONH- and C=O stretching or the N-H bending vibrations.

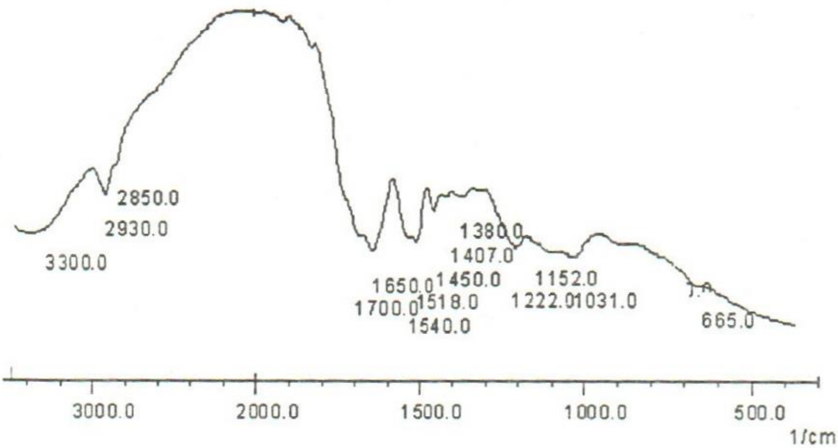

Fig. (2): Typical FT-IR spectra of extracted HA from farmyard manure compost with KOH and HNO_3

From the above data and results, it might be concluded that the elemental compositions, atomic ratio and FTIR and UV|visable absorption of HA acid extracted with KOH and HNO_3 were close to the HA extracted with NaOH and HCl. Howevere, the rich in N content may be due to the using of HNO_3.

Effect of humic substances on mineral content of the soil:

The avaliable macro and micronutrients contents of sand and loamy sand soils after treating with HAs are listed in Table (2). The results showed an increase in the nutrient contents (N,P, K, Fe, Mn, Zn and Cu) when the sandy and loamy sand soil were treated with humic substances as compared with those untreated soil. The effect was more pronounced in sandy than the loamy sand soil, which may be due to the reaction effect of soil fraction (silt and clay) and calcium carbonate in the loamy sand, which cause some inhibition for elements. The nitrogen increaed from 40 (untreated soil) to 180 (treated soil) and from 36 ppm (untreated soil) to 197 ppm (treated soil) in sandy and loamy sand soils, respectively. In sandy soil Phosphorus varied from 10.42 ppm in untreated soil to 14.58 ppm in treated soil while in loamy sand soil ranged from 8.33 ppm to 10.83 ppm in untreated and treated soil, respectively. The potassium content in soil was greatly affected with the application of HAs in both soils, the values increased from 25.59 ppm to

890.91 ppm in sandy soil and from 39.71 ppm to 633.54 ppm in loamy sand soil. The low values of Fe, Mn, Zn and Cu were 100, 620, 20 and 40 ppm, respectively for untreated sandy soil while higher values, i.e. 120, 2740, 80 and 80 ppm were deretmined in treated sandy soil. The low values of available micronutrients in untreated loamy sand soil were 40, 260, zero and 20 ppm, while the higher contents were 66.67, 623.3, 20, 33.3 ppm for Fe, Mn, Zn and Cu, respectively. The increase of the nutrients might be due to the application of humic substances or their acidifying effect on soil pH. And also humic substances buffer (neutralize) the soil and liberate carbone dioxide. Humic substances function to buffer the hydrogen ion (pH) concentration of the soil. Both acidic and alkaline soils are neutralized. Humic substances also liberate carbon dioxide (CO_2) from calcium carbonates present in the soil. The released CO_2 may be taken up by the plant or it may form carbonic acids. The carbonic acids act on soil minerals to release plant nutrients.

Table (2): Mineral contents in sandy and loamy sand soil as affected by the use of humic substances (HS).

Treatment	N	P	K	Fe	Mn	Zn	Cu
	ppm						
Sandy soil							
*Water	40	10.42	25.59	100	620	20	40
**HS	180	14.58	890.91	120	2740	80	80
Loamy sand soil							
Water	36	8.33	39.71	40	260	-	20
HS	197	10.83	633.54	66.67	623.3	20	33.3

* Soil was extracted with water at field capacity.
** Soil was extracted with HS at field capacity.

Effect of humic substances on *F. benjamina* and *Geranium sanguineum* L.:

concerning the application of humic substances on the semi-hard wood cuttings of *Ficus benjamina* and *Geranium sanguineum* L, all HS treatments gave significantly higher response than those of cuttings cultivated in untreated soils. Highly significant increase in plant height, leaf area and root mass. Significant increase in number of branches/plant were obtainted from both spieces, in addtion to roots number and root length of *Geranium sanguineum* L (Table 3&4).

In case of *F. benjamina,* the application of humic substances (Table 3) revealed that, the plant height and number of branches/plant were affected with the application of HS. The highest mean value of plant height was 14.70 cm at 6 ml HS/100 ml treatment, while the lowest value was 10.7 cm for control treatment. The number of branches/plant ranged from 2.67 to 4.00, where are the minimum and maximum values, for number of branches/plant were found for control and 6 ml HS/100 ml., respectively.

The leaf area was significantly affected by the different treatments giving the highest value with the application of 6 ml humic substances (26.7 cm^2) followed by 24.7, 24.0 and 23.3 cm^2 for 0, 2 and 4 ml treatments, respectively. While, there were no significant differences obtained between untreated cuttings (control) and either 2 or 4 ml treatments and also between using 2 ml and 6 ml for treating the cuttings on leaf area. Also, the highest fresh weight of roots (3.52 g) was obtained from cuttings treated with 6 ml humic substances, as compared with that of control treatment (1.03 g). Root number and length were not significantly affected with the application rate of any HS treatment (Table 3). The lowest values (15.0 and 17.0 cm) were obtained in the untreated plants (control), while the highest values (18.0 and 19.7 cm) were found at the 6 ml HS treatment, respectively for root number and root length.

Table (3): Effect of humic subsstance on plant height, number of branches/ plant, leaf area, root number, root length and root fresh weight of *Ficus benjamina* plant cutting.

Concentration (ml HS/100ml water)	Plant height (cm)	Branche s/plant	Leaf area (cm^2)	Root number	Root !ength (cm)	Root fresh weight (gm)
0.0	10.7	2.67	23.3	15.0	17.0	1.03
2.0	12.2	3.00	24.0	15.0	17.0	1.46
4.0	13.3	3.00	24.7	17.0	19.0	2.38
6.0	14.7	4.00	26.7	18.0	19.7	3.52
Significant	**	*	**	NS	NS	**
LSD (0.05)	2.91	1.29	2.70	-	-	0.04

L.S.D. at 0.05 level of significant.
***, ** and NS significant at P = 0.05, 0.01 and not significant, respectively.**

Restricted data in the Table (4) present the influence of HS on growth of *Geranium sanguineum* L.plant. HS treatments had significant effect on all under study properties of this plant. The highest values of root number (31.0) and length (27.0cm) were found, when plants treated with 2 ml HS/100ml, while the lowest values were obtanted from control tratment. The treated plants with 4 ml HS/100 mL showed highest response than the other plants reciving the other concentrations on the root fresh weight (4.33g), where as the lowest value (1.16 gm) was obtanted from untreated plants (control). Concerning the application of 6 ml HS/100 ml resulted in the maxmium means for plant height (25.12 cm), number of branches/plant (2.04) and leaf area (39.3 cm^2), these values were significantly higher than the control.

Table (4): Effect of humic subsstance on plant height, number of branches/ plant, leaf area, root number, root length and root fresh weight of *Geranium sanguineum* L.plant cutting.

Concentration (ml HS/100ml water)	Plant height (cm)	Number Branches/ plant	Leaf area (cm^2)	Root number	Root length (cm)	Root fresh weight (gm)
0.0	14.5	1	27.0	11.3	18.7	1.16
2.0	19.5	1.52	31.3	31.0	27.0	4.28
4.0	20.0	1.24	28.7	25.3	23.3	4.33
6.0	25.12	2.04	39.3	22.7	19.7	3.50
Significant	*	*	*	*	*	*
LSD (0.05)	8.3	2.9	6.9	11.4	7.0	0.1

L.S.D. at 0.05 level of significant.
***,** and NS significant at P = 0.05, 0.01 and not significant respectively.**

The plant height, number of branches/plant and leaf area for control plants were 14.5 cm, 1 and 27.0 cm^2, respectively. Similary results had been reported by Kononva and Pankova (1966); Dixit and Kishore (1967); Lee and Bartlett (1976); Vaughan and Malcolm (1985); Chen and Aviad (1990); and Cooper *et al.* (1998).

Effect of humic substances on nutrient contents in *F. benjamina*:

The ffect of humic substances on nutrient contents in *F. benjamina* application with irrigation water on nutrient content in plant tissues of *F. benjamina* is shown in Table (5). Significantly higher amounts of N, P, Fe, Mn, Zn, and Cu were obtained from using HS treatments, whereas there was no significant effect on K uptake. It has been proved that all elements increased with increasing the amount of humic substances applied. According to Dormar (1975), the application of HS extracted from the soil to fescue plant had a positive effect on N uptake, while the other nutrients were unaffected. While, Guar (1964) obtained increased values for N, P, and K uptake in ryegrass grown in sand amended with humic acid extracted from compost. Whether, nutrient uptake by plants increases, decreases or remains constant in response to the application of humic substances had been suggested as probably depends, on plant species and humic materials applied (Cooper *et al.*, 1998). As noted before, the application of humic substances affects the soil pH, which may, in turn, affect the availability of nutrients.

Finally, further studies on the using of HAs extracted with KOH and HNO_3 as natural fertilizers are needed to investigation their effect on the environment, improving the growth of other plants and also soil microorganisms.

Table 5: Effect of humin substances on mineral contents of *Ficus benjamina*:

Treatment (ml HS/100ml water)	N	P	K	Fe	Mn	Zn	Cu
	%			µg/g			
0.0	4.39	0.38	2.79	235	27.4	28.9	7.8
2.0	5.98	0.40	3.01	252	28.8	34.8	10.9
4.0	6.02	0.42	3.07	261	38.6	35.0	11.7
6.0	6.08	0.46	3.42	265	40.5	40.8	12.2
Significant	*	*	NS	*	**	*	*
LSD(0.05)	0.56	0.04	-	16.1	13.8	10.7	2.7

L.S.D. at 0.05 level of significant.
***,** and NS significant at P = 0.05, 0.01 and not significant respectively.**

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تأثير مستخلصات المواد الهيومية من السماد العضوى على تجذير والنمو الخضرى لكل من الفيكس بنجامينا والجرانيم سانجيم

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أجريت هذه الدراسة في صوبة بمشروع تطوير النظم الزراعية بالجيزة وذلك خلال عامين متتالين ٢٠٠٢–٢٠٠٣، ٢٠٠٣–٢٠٠٤ مستخدما مستخلص حمض الهيوميك (HA_5)من سماد الحقل لدراسة تأثيره على العناصر الغذائية بالتربة ونمو نبات الفيكس بنجامينا *F. bengamina* L والجرانيم سانجيم *Geranium sanguineum* L ومحتوى العناصر الغذائية فى نبات فيكس بنجامينا فقط.

تم استخلاص حمض الهيوميك بواسطة هيدروكسيد البوتاسيوم وحمض النتريك وتم توصيفه بالطرق الكيميائية والطرق الضوئية باستخدام الاشعة المرئية والفوق بنفسجية والتحت حمراء.

أوضحت النتائج أن قيم معامل الدبلنة ونسبة الدبلنة ونسبة حمض الهيوميك كانت ٠,٧ و ٠,٤٢ و٣٩,٣ على لتوالى ونسب العناصر فى الحمض كانت الكربون ٤٤% والنتروجين ٤,٧٣% والهيدروجين ٦,٢١% والكبريت ١,٥٢% والاكسجين ٤٣,٥٤% ونسبة الكربون :النتروجين ٩,٣٠.

انخفض الامتصاص الضوئى بزيادة طول الموجة ولا يوجد قمم امتصاص فى المدى ٣٠٠–٧٠٠نانوميتر ووجدت قمة امتصاص صغيرة قرب الطول الموجى ٢٧٠نانوميتر وكانت نسبة الامتصاص الضوئى لحمض الهيوميك عند الطول الموجى٤٤٠ و ٦٤٠ (E_4/E_6) كما أن تركيز عناصر النتروجين والفوسفور والحديد والمنجنيز والزنك والنحاس قد زادت عند معالجة التربة الرملية ووالترب اللومية الرملية بمستخلص حمض الهيوميك (pH_5) بتركيز ٦جم/لتر عند السعة الحقلية بالمقارنة بأنواع الترب المختلفة الغير معاملة وكان التأثير فى التربة الرملية أكثر وضوحا من التربة الرملية اللومية. رش مستخلص حمض الهيوميك بتركيزات ٢ ،٤، ٦مل مستخلص حمض الهيوميك /١٠٠لتر ماء قد حسن معنويا وزن الجذر وطول الجذر وعدد الجذور والمساحة الورقية وطول النبات وعدد الأفرع بالنسبة لنباتى الفيكس والجرانيم ومحتوى العناصر الغذائية فى نبات الفيكس بنجامينا.