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IMPACT OF APPLIED HUMIC AND FULVIC ACIDS ON THE SOIL PHYSIC-CHEMICAL PROPERTIES AND CUCUMBER PRODUCTIVITY UNDER PROTECTED CULTIVATION CONDITIONS

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ABSTRACT

A greenhouse experiment was carried out on a cucumber crop (Cucumber sativus) cultivated in a clay loam soil at Bahtim, Agricultural Research Station during the growing season of 2010 to study the effect of humic and fulvic acids on physico-chemical properties and cucumber yield. The experiment contained two active organic acids treatments, i.e., humic acids as K-humate or fulvic acids as K-fulvate were used as soil application and foliar spray as solely treatment or incorporated together at five rates of 0, 5, 10, 15 and 20 L fed^{-1} from humic or fulvic acids as soil application or (0, 50, 100, 150 and 200 ppm) as foliar spray as compared with the combined treatment on some physical properties i.e., bulk density, total porosity, moisture constants (field capacity, wilting point and available water), hydraulic conductivity and chemical properties i.e., pH, EC, organic matter and availability of N, P and K in clay loam soil. On the other side, the positive effect of these treatments on cucumber yield and its content of nutrients were taken into consideration.

Generally, results indicated that application of organic acids as soil application incorporated with foliar spray was more effective on improving soil and plant parameters under studied, followed by soil and foliar application as solely treatment, especially at the fourth rate of 20 L fed^{-1}as soil application and 200 ppm as foliar spray. However, the obtained results showed that, the addition of humic or fulvic acids were positively affect on cucumber fruit yield as well as its contents of carbohydrate, protein % and NPK. Also, the best applied method for humic or fulvic acid was achieved when they was added as soil application combined with foliar spray, however, the greatest values of fruit yield of cucumber, total or soluble carbohydrate, protein % and NPK content in both shoot and fruit were obtained at the takes of 15 L fed^{-1} and 150 ppm for humic and fulvic acids as soil application combined with foliar spray, respectively.

Keywords: humic acids, fulvic acids, methods of application, cucumber yield, NPK,

INTRODUCTION

Beneficial effects of humic substances on plant growth have been recognized by many workers but specific effects of these substances on various phases of plant growth and on nutrient uptake have not been adequately investigated. Applications of humic substances to soils low in organic matter, or in nutrient solutions, have produced very significant responses. Improving soil conditions and establishing the equilibrium among plant nutrients are important for soil productivity and plant production. Soil organic matter increases agricultural production by improving soil physical, chemical and biological properties. Application of organic residues could increase soil organic matter (SOM), buffer the soil, improve aggregate stability and enhance water-retention capacity (Spaccini *et al.,* 2002).

Humic compounds may be absorbed by roots and translocated to shoots, thus enhancing the growth of the whole plant. It has also been suggested that plant growth is influenced by increasing the absorption of ions, by facilitating the distribution of heavy metals as chelates within the plant and by affecting metabolic reactions (Rauthan and Schnitzer, 1981). 9Humic substances are organic compounds that result from the decomposition of plant and animal materials. Humic acid and their salts which derived from coal and other sources may provide a viable alternative to liming, to ameliorate soil alkalinity and improve soil structure stability. Research has shown it is the humic substances fractions (humic acid, fulvic acid and humin) of the soil organic matter that are responsible for the generic improvement of soil fertility and improved productivity (Fortun *et al.* 1989).

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 and Ayuso *et al.,* 1996). Nair, (1995) attributed the favorable effect of foliar spraying of humic acid on the crop yield to the increased content of chlorophyll in the leaves and enhanced photosynthetic activity and higher uptake of nutrients like P. The same author added that humic acids are known to posses many beneficial agricultural properties, they participate actively in the decomposition of organic matter, rocks and mineral, improve soil structure and change physical properties of soil, promote the chelation of many elements and make these available to plants, aid in correcting plant chlorophyll enhancement of photosynthesis density and plant root respiration, which has resulted in greater plant growth with humate application. The humic acid hydrophilic groups (carboxyl and phenols) attract hydration water, thus increasing the water retention capacity in soils (Stevenson, 1994). Haripriya *et al.,* (2002) reported that the increased yield might be due to the efficient utilization of nutrients, improved aeration and water holding capacity as observed in the humic acid applied treatments.

Many studies were carried out on the favorable effect of humic substances as related to plant growth. (Manuel *et al.,* 1991) pointed out that humic substances produced highly significant increases in the growth of cucumber plant tops and roots as well as in the stem height, the number of flowers per plant and the leaf size. The addition of humic substances also resulted in an increase in the nutrients content of N, P. K, Ca, Mg and Fe in the roots as well as and also in the N, P and Fe contents in the shoots. Chen and Solovitch (2005) studied the effect of foliar application of nutrient solution of humic substances on plants growth. They found that enhanced growth of young tomato and sugar beet leaves resulted from foliar spray of HS. nutrient uptake, height of shoots and the number of flowers of cucumber plants increased as a result of the presence of fulvic acid at concentrations of up to 300 mg L^{-1} in the nutrient solution.

Sivakumar and Devarajan (2005) studied the influence of k-humate on the yield and nutrient uptake of rice. The data on the grain yield showed a marked increase for the application of humic acid up to 20 kg HA ha^{-1} beyond which there was a marginal decline in the yield. With regard to the mode of application of humic acid, it showed that the humic acid applied 10 kg ha^{-1} coupled with foliar spray (FS) or root dropping (RD) or both, registered a significant increase in the grain yield than 10 kg HA ha^{-1} (soil application) alone. Verónica *et al.* (2010) indicated that the beneficial effects of humic substances on shoot development in cucumber could be directly associated with nitrate-related effects on the shoot concentration of several active cytokines and polyamines (principally putrescence).

So it should be recommended that using humic or fulvic substances as soil application or spraying on the plant is of importance for ameliorating soil and plant characteristics. Thus, this study aims to identify the best method and concentration of humic or fulvic acids application for cucumber plants grown under protected conditions.

MATERIALS AND METHODS

To achieve the previous target, a greenhouse experiment was carried out on cucumber (*Cucumis Saliva*) crop cultivated on alluvial soil at Bahtim, Agricultural Research Station during the growing winter season of 2010 to study the effect of applied methods (foliar spray or soil application and together) through different levels from humic and fulvic acids on some soil physic-chemical properties and cucumber productivity as well as fruit content of NPK %.

The studied area is bounded by longitude of 31^0 15.54^- East and latitude of 30^0 8.15^- North, land elevation 52 m. Some soil physical and chemical properties were determined according to Page *et al.* (1982) and the obtained data are presented in Table (1). Cucumber (*Cucumber sativus,* Nickerson Zwan cv.) N/Z 51- 466 was planted at 50 cm apart between hills in the prepared plots, each plot has a size of 6 m^2 (three rows 65 cm apart and 3 m long). The experiment was arranged in a split split plot design with 3 replications. The main treatment cucumber treated in four batches by two treatments (humic or fulvic acids). Sub treatments were three applied methods (foliar spray or soil application and together). Sub sub treatments were five rates (C1, C2, C3, C4 and C5) of 0, 5, 10, 15 and 20 L fed^{-1} for humic or fulvic acids diluted with tap water at a rate of 1 (organic acids): 20 (water) as soil application to the cucumber growing on a clay loam soil under protected conditions or (0, 50, 100, 150 and 200 ppm) as foliar spray as compared to combined method of foliar spray and soil application.

The soil plots were irrigated at least every two days. All plots, received the fertilizers requirements as recommended for cucumber. All plots were received 60 kg P_2O_5 fed^1 in the form of super phosphate (15 % P_2O_5) with recommended dose for FYM 40 m^3 fed^{-1} cattle wastes before planting. While, nitrogen fertilizer was applied at rate 180 kg of N fed^{-1} as ammonium nitrate (33 % N) into three equal doses; i.e., at two weeks after planting, the begging of fruit and two weeks latter. Potassium fertilization was applied in the form of potassium sulphate (48 % K_2O) at 60 kg K_2O fed^{-1} at, into two equal doses, i.e., before planting and one month latter.

The time from cucumber planting to first harvest was 70 days. The frequency of harvest was usually every other day depending on weather. At harvest time, weight of fruits per each plot was recorded. After harvest of cucumber, fruits and shoots samples were washed with tap water, distilled water, air-dried (fruit samples cutting to slides), oven dried at C^o 70^o, and then ground in a stainless steel mill and the powder stored for elemental analysis. The plant powder was digested with concentrated H_2SO_4 and H_2O_2 as described by Page *et al.* (1982) to measure macronutrients (N, P and K) using the procedure described by Ryan *et al.* (1996). Total protein in cucumber fruit were calculated by multiplying nitrogen % in 6.25 as described by Stewart (1989).

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

Characteristics	Value	Characteristics	Value
Particle size distribution %		**pH (in soil pest)**	7.52
Sand coarse	7.20	**EC dsm^{-1}**	6.30
Sand fine	23.5	**Cations and anions (m mol L^{-1})**	
Silt	31.7	**Ca++**	23.6
Clay	37.6	**Mg++**	9.50
Texture	Clay loam	**Na+**	26.1
Bulk density (g/cm^{-3})	1.48	**K+**	0.85
Total porosity %	44.15	**SO4--**	28.5
Hydraulic conductivity cm/hr^{-1}	4.50	**Cl-**	32.3
Field capacity %	30.77	**HCO_3-**	2.25
Wilting point %	12.85	**CO3-**	-
Available water %	17.92	**Chemically available (mg k^{-1} soil)**	
$CaCO_3$ %	3.02	**N**	59.8
O.M %	0.75	**P**	9.24
		K	394.5

Surface soil samples (0-30 cm layer) were collected from each plot after harvesting, and then air-dried to determine some physical and chemical properties i.e., particle size distribution which was carried out by the pipette method described by Gee and Bauder (1986), bulk density, total porosity, hydraulic conductivity, moisture constants (field capacity (FC), wilting point (WP) and available water (AW)) as described by Black (1983) and Stakman and Vanderhast (1962).

Chemical properties, i.e., soil pH, electrical conductivity (EC) in soil paste extract as dsm^{-1} (Jackson, 1973), organic matter, available N, P and K and total calcium carbonate according to the methods described by Page *et al.* (1982).

Table (2): Some chemical analysis of the used humic and fulvic acids

Characteristics	pH	EC (dSm^{-1})	O.C %	N %	P %	K %	Fe mg/L^{-1}	Mn mg/L^{-1}	Zn mg/L^{-1}	Cu mg/L^{-1}
Humic acid	3.23	4.6	9.5	1.29	0.15	0.98	66.8	10.6	1.90	0.06
Fulvic acid	7.56	6.15	4.2	0.42	0.25	1.79	92.3	11.6	2.65	0.36

All data were subjected to statistical analysis of variance and treatment means were compared using Mstatc computer package to calculate F ratio according to the Least Significant Differences (L.S.D.) test method as described by Snedecor and Cochran (1980).

RESULTS AND DESSICION

Physical properties of soil

Data in Table 3 indicated the effect of humic and fulvic acids on bulk density (B.D) g cm^{-3}, total porosity (T.P) %, hydraulic conductivity (H.C) cm hr^{-1}, field capacity (F.C) %, wilting point (W.P) % and available water (A.W) %. Generally, the application of humic and fulvic acids were slightly improvement of physical properties under study, especially of humic acids than fulvic acids it's could be due to the organic carbon content of humic acids were greater than fulvic acid has a great influence on soil amelioration, due to its carboxyl and phenolic- or group's that interact with various soil components (Metin *et al.,* 2005). The soil incorporated with foliar application was more effective on physical properties followed by soil application, while the minimum values were due to foliar application. Results in Table 3 indicated that the application of humic or fulvic acids as soil and foliar application were highest decreased of bulk density, on the other side increased of total porosity. This effect increased with increase of application rate, the application of humic and fulvic acids at a rate of 20 L fed $^{-1}$ as soil application and 200 ppm as foliar application together were more effective on decreased of bulk density, the decrease percentage was record 2.86 and 2.81 %, respectively, as compared to control (C1). Data in Table 3 indicated the decreased of bulk density in the same time increased of total porosity, humic acids as K-humate was slightly increased of total porosity as compared to fulvic acids. Total porosity percentages were more responding to soil and foliar application followed soil application only combined with foliar spray. Minimum values of total porosity were observed due to foliar application both humic and fulvic acids. The increase of total porosity increased with increased of rate application both humic and fulvic acids especially when soil application combined with foliar one. Bauer and Black (1992) stated that increasing organic matter decrease bulk density and consequently increase soil total porosity. They added that soil organic matter influences on water movement in soil because of its hydrophilic character and its effect on soil structure and bulk density.

As regards to hydraulic conductivity, same trend in total porosity was clear in Table 3 showed that, the hydraulic conductivity more responsibly to humic acids as compared to fulvic acid may due to the organic carbon greater in humic than fulvic acids. Generally, the soil application of humic or fulvic acids at a rate of 20 L fed^{-1} incorporated with 200 ppm as foliar spray more effective on increased of hydraulic conductivity, followed by soil application and foliar spray was lowest affect than other methods. Also, the results indicated that significant effect on hydraulic conductivity due to different methods and rates application of organic acids under study.

Table (3): Effect of different application methods and concentration of humic and fulvic acids on same physical properties of alluvial soil.

Treatments (A)	Con*. (C)	Physical properties					
		B.D* g /cm^3	T.P* %	H.C* cm /hr^{-1}	F.C* %	W.P* %	A.W* %
Soil application (B)							
Humic acid	control	1.43	46.04	4.61	33.01	13.00	20.00
	5 L/ fed	1.42	46.42	4.66	33.45	13.09	20.36
	10 L/ fed	1.41	46.79	4.73	33.78	13.12	20.66
	15 L/ fed	1.40	47.17	4.82	34.23	13.34	20.89
	20 L/ fed	1.39	47.55	5.01	34.47	13.41	21.06
mean		1.41	46.79	4.75	33.79	13.16	20.59
Fulvic acid	control	1.45	45.28	4.56	32.71	12.91	19.80
	5 L/ fed	1.44	45.66	4.59	32.85	13.02	19.83
	10 L/ fed	1.43	46.04	4.60	33.08	13.10	19.98
	15 L/ fed	1.42	46.42	4.61	33.14	13.12	20.02
	20 L/ fed	1.41	46.79	4.63	33.23	13.17	20.06
mean		1.43	46.04	4.60	33.00	13.06	19.94
Foliar spray application (B)							
Humic acid	control	1.48	44.15	4.51	30.78	12.86	17.92
	50 ppm	1.48	44.15	4.57	30.84	12.89	17.95
	100 ppm	1.47	44.53	4.59	31.04	12.90	18.14
	150 ppm	1.46	44.90	4.61	31.12	12.92	18.20
	200 ppm	1.46	44.90	4.62	31.19	12.93	18.26
mean		1.47	44.53	4.58	30.99	12.90	18.09
Fulvic acid	control	1.47	44.15	4.52	30.78	21.86	17.92
	50 ppm	1.47	44.25	4.53	30.80	12.88	17.90
	100 ppm	1.46	44.35	4.55	30.91	12.89	18.02
	150 ppm	1.46	44.45	4.56	30.94	12.90	18.03
	200 ppm	1.46	44.53	4.57	31.02	12.91	18.11
mean		1.46	44.35	4.55	30.89	14.69	18.00
Soil and foliar spray application (B)							
Humic acid	control	1.4	47.17	4.87	34.57	13.65	20.92
	C2 S + F	1.39	47.55	4.92	34.79	13.72	21.07
	C3 S + F	1.38	47.92	5.02	34.93	13.75	21.18
	C4 S + F	1.37	48.30	5.23	35.15	13.81	21.34
	C5 S + F	1.36	48.68	5.43	35.24	13.85	21.39
mean		1.38	47.92	5.09	34.94	13.76	21.18
Fulvic acid	control	1.42	46.42	4.75	33.57	13.05	20.52
	*C2 S + F	1.40	47.17	4.82	33.75	13.13	20.62
	C3 S + F	1.39	47.55	4.91	34.31	13.24	21.07
	C4 S + F	1.39	47.55	4.93	34.45	13.28	21.17
	C5 S + F	1.38	47.92	4.97	35.24	13.34	21.90
mean		1.40	47.32	4.88	34.26	13.21	21.06
L.S.D. 0.05							
Treatments (A)		**	**	**	**	**	**
Application methods (B)		0.01	0.01	0.01	0.17	0.13	0.04
Concentration (C)		0.01	0.01	0.03	0.14	0.03	0.03
Interactions (ABC)		0.64	0.06	0.20	0.26	0.20	0.06

*** B.D= Bulk density** *** T.P= Total porosity**
***H.C= Hydraulic conductivity** ***F.C=Field capacity**
***W.P= wilting point** ***A.W= available water**
C S+F=soil and foliar applications concentrations ***C = concentration**

Available water capacity is the maximum amount of plant available water a soil can provide. It is an indicator of a soil's ability to retain water and make it sufficiently available for plant use. Available water capacity is the water held in soil between its field capacity and permanent wilting point. Field capacity is the water remaining in a soil after it has been thoroughly saturated and allowed to drain freely, usually for one to two days. Permanent wilting point is the moisture content of a soil at which plants wilt and fail to recover when supplied with sufficient moisture. Regardless of methods and rates application, data in Table 3 showed that, the application of humic acids was positive effect on moisture constants i.e., field capacity (FC), wilting point (WP) and available water (AW). Stevenson, (1994) reported that, the humic acid hydrophilic groups (carboxyl and phenols) attract hydration water thus increasing the water retention capacity in soils. Soil application at a rate of 20 L fed^{-1} both humic and fulvic acids and incorporated with 200 ppm as foliar spray more effective on increase of FC and AW and decreased of WP followed by soil application alone . Minimum values were recorded due to foliar application of humic and fulvic acids as compared to control treatment.

From above results mentioned, it was noticed that, the application of humic acids as soil application at a rate 20 L fed^{-1} and incorporated with 200 ppm as foliar spray were more effective on bulk density, total porosity, hydraulic conductivity, field capacity, wilting point and available water may be due to higher content of organic carbon in humic acids as compared to fulvic acid. Indirectly, organic matter improves soil structure and aggregate stability, resulting in increased pore size and volume. These soil quality improvements result in increased movement of water through the soil, and available water capacity, (Stevenson, 1994). Rawls *et al.,* (1992) studied the relationships between field capacity, wilting point and available water from side and some soil properties from the other one. They found that these constant could be determined by means of developed regression models. Any increase in organic matter by a unit cause a relatively large increase in the percentage of water retained in soil at the field capacity than at wilting point in coarse textured soils and the opposite was true in case of fine textured ones where showed increased in wilting point with increasing organic matter by a unit (Bauer and Black, 1992).

Chemical properties of soil

Data in Table 4 indicated that the effect of humic and fulvic acids on pH, EC, organic matter content and available of N, P and K in alluvial soil planted by cucumber.

Effect of humic and fulvic acids added on pH, EC and organic matter (OM) content.

Generally, data in Table 4 indicated that, positive effect on pH values, EC values and increase OM content in soil under study after harvest due to application both humic and fulvic acids. Use of humic acids as K-humate was more effective on decreased of EC and increased of OM in soil, as compared to fulvic acids, while the pH decrease more responded to fulvic acid, this different effects both humic and fulvic acids may be due to different activity of microorganisms during demonstrated of humic matter in soil and buffering pH. Lowering soil pH value through yielding intermediate organic acid as well as increasing the activity of soil organisms to liberate more nutrients from the unavailable reserves (Modaihsh *et al.* 2005). Decreased EC could be due to the increased permeability leading to leaching of salts (Deepa, 2001). On the other side, the humic acids was positive effect on increase of OM as compared to fulvic acids, and it might be due to the reduced microbial population at higher level of HA (Deepa, 2001). The positive effect might be due to the high content of organic carbon (data in Table 2) in the potassium humate itself. Also, decrease EC values and increase OM content in soil used indicate the positive effect in addition, humic and fulvic acid are the most significant component of organic substances (Mecan and Petrovic, 1995), so, their application particularly as soil treatment, effectively minimized the negative effects of salinity.

On the other hand, soil application of humic acid at a rate of 20 L fed^{-1} (C5) combined with foliar application at a rate of 200 ppm (C5) were more effect to decrease of pH and EC and increase of OM in soil followed by soil application and foliar spray was low effect on same parameters. While, pH, EC and OM were more responded due to fulvic acids as soil application at a rate of 15 L fed^{-1} (C4) incorporated with 150 ppm (C4) as foliar application. According to the effect of application methods data in (Table 4) concluded that, best application method of humic and fulvic acids were ranked in an order of soil combined with foliar added > soil added alone > foliar added alone.

Effect of humic and fulvic acids added on available N, P and K in soil.

Regardless of methods and rates application, humic and fulvic acids had positive effect on increase of available N, P and K in alluvial soil planting of cucumber plants.

Data in Table 4 indicated the significant increased of available N and P due to application of humic acids, while fulvic acids was more effectively on available K. There are several reports to show that mineralization of N, P and K from the soil into the root system is increased in the presence of humus substances. Humic substances derived from brown coal (lignite) are a rich source of acidic carboxylic and phenolic groups which can provide reactive sites for cation exchange, bind and sequester phytotoxic elements, increase pH buffering of soils, and promote the penetration and retention of calcium in the soil as well as improve nutrient transport to plants, (Wang *et al.,* 1995).

As regard to methods and rate of application, the results indicated that the soil application combined with foliar one were favorable to significant increase available of N, P and K both humic and fulvic acids followed by soil application and foliar one individually. The availability increase with increasing at rates application of humic and fulvic acids, also, fulvic acids (FA) which is known to be surface active, could have increased the permeability of root membranes and so enhanced nutrient uptake. Additional plausible explanations for the activity of FA are that it contains structures that act like hormones, that it facilitates the translocation of nutrients throughout the plant, and that by complexing with metal ions it increases their solubility and availability to plant roots.

The application of >150 ppm of FA appears to provide more ligands with which the metal ion can complex so that the metals becomes less available to plant roots, (Rauthan and Schnitzer, 1981). In the other words, the soil application of fulvic acid at a rate of 15 L fed^{-1} compined with 150 ppm as foliar application were more effective on available of N, P and K, while, humic acids was favorable in highest application rate.

On the other hand, regardless application of rate, data in Table 4 showed that the soil application combined with foliar one both humic and fulvic acids were significant increase of available N. The increase in available N might be attributed to the N contributed from the native N by the enhanced microbial activities induced by the humic acid (Deepa, 2001). The increase in the availability of P could be attributed to the chemical and biochemical processes involved. The humic acids might have helped in solubilizing P from insoluble to soluble form resulting in its increase. Similar increase was reported by Khan *et al.,* (1997) for the application of metal humates up to 50 ppm.

P availability increased due to application of humic and fulvic as soil application combined with foliar one, (data in Table 4). The reason attributed was phosphate ions were expected to interact with humic acid more through its phenolic and hydroxyl groups which might have changed the behaviour of P. The presence of such functional groups as assessed by infrared spectra analysis would confirm similar action in the treated soil leading to increased P availability. David *et al,.* (1994) found that humus would form protective coating over sesquioxides and thereby reducing the fixation of any phosphate, which made them available in the soil. The increase in available P might also be due to the mineralization of soil organic P (Dusberg *et al.,* 1989) as well as humic acid (Vaughan and Ord, 1985). Thangavelu and Manickam (1989) reported that, the P availability was increased with application of manure due to less fixation and release of P by humic substances released during mineralization of organic matter.

The results in Table 4 indicated the significant increase of availability K due to application both humic and fulvic acids. The humic and fulvic acids are believed to play a definite role in liberating fixed K because of their high complexing power. In addition, the lower molecular weight fractions of humic compounds are capable of penetrating the intermicellar spaces of expanding types of clays and reach the specific sorption sites for K, where they might react or compete for sites with K and increase its availability in soil (Tan and McCreery, 1975). The enhanced microbial activity due to humic acid application would also have paved way for the increased availability of K through reducing its fixation in the soil and dissolution of fixed K. Tan (1978) reported that, at pH 7.0, humic and fulvic acids were capable of dissolving small amounts of K from the minerals by chelation, complex reactions or both. The accentuated biotic activity (Deepa and Govindarajan, 2002) by HA application and greater increase in soil microbial biomass might have been paved way for concomitant increase in the organic carbon content.

It is found from the results in Table 4, that the application of humic and fulvic were positive effect on decreased of pH and EC, while increased both organic matter content and available N, P and K, were order N > P > K, especially soil application combined foliar one followed soil and foliar application individually. Application rates were slightly difference between of humic and fulvic acids depended on microbial activity, presence of functional groups and chelation, complex reactions or both.

Table (4): Effect of different application methods and concentration of humic and fulvic acids on some chemical properties of alluvial soil

Treatments (A)	Con. (C)	pH (1:2.5)	EC dS/cm	O.M %	Available mg kg^{-1} soil N	P	K
Soil application (B)							
Humic acid	control	7.50	6.01	0.83	61.23	9.75	415
	5 L/ fed	7.48	5.82	0.85	63.24	9.83	425
	10 L/ fed	7.46	5.73	0.87	64.57	9.91	433
	15 L/ fed	7.45	5.66	0.89	64.87	10.03	453
	20 L/ fed	7.43	5.57	0.92	65.15	10.12	459
mean		7.46	5.74	0.87	63.81	9.93	437
Fulvic acid	control	7.51	6.18	0.78	61.5	9.55	407
	5 L/ fed	7.50	6.12	0.80	61.74	9.73	413
	10 L/ fed	7.84	6.10	0.83	62.07	9.89	430
	15 L/ fed	7.45	5.96	0.87	63.17	9.97	447
	20 L/ fed	7.47	6.06	0.85	62.35	9.92	439
mean		7.55	6.08	0.83	62.17	9.81	427
Foliar spray application							
Humic acid	control	7.51	6.28	0.76	59.84	9.35	396
	50 ppm	7.50	6.20	0.77	60.02	9.42	401
	100 ppm	7.49	6.12	0.78	60.35	9.48	408
	150 ppm	7.49	6.09	0.79	60.56	9.70	410
	200 ppm	7.48	6.01	0.79	60.75	9.83	413
mean		7.49	6.14	0.78	60.30	9.56	406
Fulvic acid	control	7.51	6.29	0.76	59.81	9.28	396
	50 ppm	7.50	6.28	0.76	59.97	9.32	399
	100 ppm	7.49	6.26	0.77	60.05	9.42	402
	150 ppm	7.49	6.19	0.78	60.17	9.64	412
	200 ppm	7.50	6.21	0.77	60.12	9.53	409
mean		7.50	6.25	0.77	60.02	9.44	404
Soil and foliar spray application							
Humic acid	control	7.45	5.75	0.85	63.45	10.38	421
	C2 S + F	7.43	5.53	0.89	65.23	10.84	434
	C3 S + F	7.40	5.34	0.91	66.34	11.05	452
	C4 S + F	7.38	5.12	0.93	68.93	11.57	487
	C5 S + F	7.34	4.86	0.95	73.25	12.02	512
mean		7.40	5.32	0.91	67.44	11.17	461
Fulvic acid	control	7.48	5.87	0.80	62.75	10.03	415
	C2 S + F	7.47	5.64	0.82	62.86	10.34	423
	C3 S + F	7.46	5.54	0.85	64.04	10.75	447
	C4 S + F	7.43	5.43	0.90	67.13	10.97	475
	C5 S + F	7.45	5.51	0.87	65.64	10.81	464
mean		7.46	5.60	0.85	64.48	10.58	445
L.S.D. 0.05							
Treatments (A)		NS	**	NS	**	**	**
Application methods (B)		NS	0.004	0.001	0.08	0.04	1.12
Concentration (C)		NS	0.003	0.001	0.07	0.03	0.93
Interactions (ABC)		NS	0.006	0.002	0.13	0.006	1.98

Humic and Fulvic Acids Use Efficiency on Cucumber Yield.
Fruit Yield, Carbohydrate and Protein Content.

Data presented in Table 5, show the effect of the addition of both humic and fulvic acids on the cucumber growing in clay loam soil under protected conditions where results showed that, the addition of humic and fulvic acids, regardless of method and rate application, positively increased fruit yield, carbohydrate and protein content of cucumber comparing with control plants. The positive effect may be attributed to improve productivity of cucumber yield as indirectly result to use humic and fulvic acids and improved chemical and physical properties of the soil as well as direct the positive impact on cucumber plant physiological resulting from the improved conditions of absorption of necessary elements for plant growth. This result was confirmed with the results obtained by Chen and Aviad (1990) concluded that humic acid correcting plant chlorosis and thus enhanced photosynthetic potential as well as increasing total sugar content in plants. The favorable effects of humic acid on increasing protein concentration in pods might be due to their effect on improving soil nitrogen uptake and encourage potassium, calcium, and magnesium and phosphorus availability to plant root system (Seginer *et al.,* 1998 and Pascual *et al.,* 1999). The increase in cucumber production (fruits yield and total, soluble carbohydrate and protein (%)) due to humic and fulvic acids application increase the uptake of nutrient elements from the surrounding nutrient solution with a concomitant increase in physiological processes (Alianiello *et al.,* 1991 and Verónica *et al.,* 2010).

Also, data in Table 5 show that, the application of both humic and fulvic acids as soil application incorporated with foliar application compared with soil and foliar application individually on the cucumber growing in clay loam soil under protected conditions. Data indicated that, there are significant differences between the application methods of humic and fulvic acids on fruit yield kg/plant^{-1} but unsignificant differences were found between application methods on total, soluble carbohydrate (mg g^{-1}) and protein (%) of cucumber fruit.

Generally, best application method of humic and fulvic acids was soil application incorporated with foliar application. It is clear that the common benefit of added of humic and fulvic acids into the soil improve the physical and chemical properties and interest physiological resulting from spray shoots has led to significant differences in each of the production fruit of cucumber and increased content of protein and sugars compared with added to soil or spray alone. These results were confirmed with obtained by Cacco and Dell Agnolla (1984) and Russo and Berlyn (1990) who concluded that, humic substances such as humic acid and fulvic acid, are the major components (65-70 %) of soil organic matter, increase plant growth enormously due to increasing cell membrane permeability, respiration, photosynthesis, oxygen and phosphorus uptake, and supplying root cell growth, this in case soil added. On the other hand, foliar application has been used as a means of supplying supplemental doses of minor and major nutrients, plant hormones, stimulants, and other beneficial substances.

Table (5): Effect of different application methods and concentration of humic and fulvic acids on yield kg/plant^{-1} and element content of cucumber planted on alluvial soil under protected cultivation conditions.

Treatments (A)	Con. (C)	Fruit yield of cucumber				Element content of cucumber %					
		Kg / Plant^{-1}	Carbohydrate		protein	Fruit			shoot		
			Total mg/g	Soluble mg/g	% on dry weight	N	P	K	N	P	K
Soil application (L/fed) (B)											
Humic acid	control	2.49	84	10.95	10.90	1.51	0.48	1.88	3.64	0.44	1.47
	5/L	3.37	113	11.90	12.90	1.88	0.55	1.90	3.81	0.52	2.35
	10/L	3.38	129	12.00	13.95	2.03	0.65	2.12	3.87	0.58	3.12
	15/L	3.54	132	12.65	16.90	2.30	0.77	2.33	4.46	0.61	5.35
	20/L	3.08	118	11.70	13.95	2.01	0.70	2.22	3.84	0.41	4.77
mean		3.17	115	11.84	13.72	1.95	0.63	2.09	3.92	0.51	3.41
Fulvic acid	control	2.75	84	10.95	13.20	1.82	0.44	1.72	3.27	0.38	1.80
	5/L	3.24	101	11.25	13.90	1.93	0.64	1.80	3.35	0.42	3.00
	10/L	3.45	118	11.50	16.45	2.33	0.66	2.06	3.71	0.60	3.06
	15/L	3.47	127	12.40	18.20	2.50	0.78	2.44	4.62	0.79	4.49
	20/L	3.03	126	11.55	17.60	2.50	0.77	2.14	4.23	0.64	4.23
mean		3.19	111	11.53	15.87	2.22	0.66	2.03	3.84	0.57	3.32
Foliar spray application (ppm) (B)											
Humic acid	control	3.07	84	10.85	11.80	1.68	0.51	1.73	3.45	0.43	1.47
	50	3.58	100	11.90	13.35	1.85	0.61	1.94	3.79	0.47	2.66
	100	3.65	131	11.95	14.65	2.03	0.70	2.03	4.03	0.53	3.47
	150	3.76	135	13.00	14.80	2.06	0.78	2.44	4.16	0.58	4.61
	200	3.53	107	11.35	12.50	1.74	0.75	2.20	3.88	0.54	4.18
mean		3.52	111	11.81	13.42	1.87	0.67	2.07	3.86	0.51	3.28
Fulvic acid	control	2.86	84	10.95	13.00	1.81	0.44	1.66	3.51	0.38	1.10
	50	3.65	101	11.10	13.90	1.93	0.64	1.67	3.64	0.49	3.11
	100	3.66	115	11.60	16.10	2.23	0.66	1.91	3.82	0.61	3.49
	150	3.68	120	12.00	17.35	2.42	0.77	2.11	4.23	0.72	3.62
	200	3.19	119	11.65	16.80	2.34	0.76	1.88	3.92	0.58	3.83
mean		3.41	108	11.46	15.43	2.15	0.65	1.84	3.82	0.55	3.03
Soil and foliar spray application (B)											
Humic acid	control	3.15	89	10.95	11.10	1.52	0.47	1.62	3.54	0.41	1.40
	C2 S+F	3.70	123	12.35	13.50	1.80	0.57	1.81	3.73	0.52	2.58
	C3 S+F	3.19	143	12.50	14.65	1.93	0.65	2.50	4.13	0.61	3.47
	C4 S+F	4.19	145	13.00	16.55	2.43	0.77	2.61	4.71	0.63	5.99
	C5 S+F	3.35	114	11.70	14.40	2.22	0.73	2.40	4.01	0.46	4.42
mean		3.52	123	12.10	14.04	1.98	0.64	2.19	4.02	0.53	3.57
Fulvic acid	C1 S+F	3.24	84	10.95	13.05	1.84	0.61	1.67	3.47	0.35	1.86
	C2 S+F	3.95	117	11.40	13.95	1.93	0.67	1.87	3.58	0.50	2.90
	C3 S+F	4.22	120	11.85	16.80	2.28	0.68	2.16	3.82	0.65	3.31
	C4 S+F	4.32	124	12.95	17.50	2.62	0.79	2.39	3.80	0.78	4.99
	C5 S+F	3.72	123	11.65	17.45	2.46	0.77	2.17	4.57	0.63	4.23
mean		3.89	114	11.76	15.75	2.23	0.70	2.05	3.85	0.58	3.46
L.S.D. at 5%											
Treatments (A)		NS	**	**	**	**	**	**	**	**	**
Application methods (B)		0.32	NS	NS	NS	0.07	0.03	0.02	0.01	0.01	0.09
Concentration (C)		0.28	5.62	0.44	1.31	0.10	0.05	0.13	0.21	0.08	0.68
Interactions (ABC)		0.12	NS	NS	NS	NS	NS	NS	NS	NS	NS

C S+F=soil and foliar applications concentrations

Observed effects of foliar fertilization have included yield increases, resistance to diseases and insect pests, improved drought tolerance, and enhanced crop quality. In terms of nutrient absorption, foliar fertilization can be from 8 to 20 times as efficient as ground application (Anonymous. 1985).

According to data in Table 5, the effect of use five addition rates (C1, C2, C3, C4 and C5) were (0, 5, 10, 15 and 20 L fed^{-1}) from humic and fulvic acids as soil alone on the cucumber growing in clay loam soil under protected conditions or (0, 50, 100, 150 and 200 ppm) as foliar alone compared with soil application combined with foliar one. Results in Table 5 indicated that the application rates of humic and fulvic acids significant increase on fruit yield kg $plant^{-1}$ and total soluble carbohydrate (mg g^{-1}) and protein (%) of cucumber fruit. The highest values in fruit yield of cucumber kg/$plant^{-1}$ and total soluble carbohydrate (mg g^{-1}) and protein (%) were due to C4 addition at a rate of 15 L fed^{-1} added as soil application combined with foliar application at a rate of 150 ppm from humic and fulvic acids. This result was in agreement with Atiyeh *et al.,* (2002) found that, increased the growth of tomato and cucumber plants significantly with increasing concentrations of humic acids treatments of the plants with 50–500 mg kg^{-1} humic acids, but often decreased significantly when the concentrations of humic acids 500 – 1000 mg kg^{-1} . Sahar Zagloul *et al.,* (2009) revealed that, the highest shoots sugar content of thuya orientalis, L. was obtained from plants treated with 2.0 or 2.5% potassium humate.

At the same time as data in Table 5 revealed that, the interaction between addition methods and application rates of humic and fulvic acids on fruit yield of cucumber kg/$plant^{-1}$ were significant but the increases were non significant with total soluble carbohydrate (mg g^{-1}) and protein (%) respectively. Rauthan and Schnitzer (1981) concluded that, maximum growth of cucumber shoots occurred at concentrations of 100 to 300 mg L^{-1} fulvic acid and attributed these substances can either have a direct effect such as absorption of the humic compounds by the plant, affecting certain enzymatic activities, membrane permeability, etc or an indirect (changes in the soil structure, increased cationic capacity, stimulation of microbiological activity the capacity to solubilize or complex certain soil ions) effect on the plant.

Nutrient content:

Data in Table 5 showes the comparing effect of humic and fulvic acids addition on N, P and K contents % in shoot and fruit of cucumber growing in clay loam soil under protected conditions. Generally, the addition of humic and fulvic acids positively increased N, P and K % in both shoot and fruit of cucumber plant compared with control. This result reflects the positive relationship between the increases of nutrients availability in the soil with increased absorption of these elements by plant. Results also indicated that, there is significant difference between the use of humic and fulvic acids, this result in the same lain with obtained by David *et al.* (1994) who concluded that, humic substances promoted growth and more mineral nutrient uptake of plant due to the better developed root systems. In study, higher doses of HA had less effects on growth criteria in pepper seedling. Asik *et al.,* (2009) determined that under salt stress, the lowest doses of both soil and foliar application of humic substances increased the nutrient uptake of wheat.

On the other hand, data reveal that, significant differences between the methods addition of humic and fulvic acids on N, P and K % in shoot and fruit of cucumber growing in clay loam soil under protected conditions. Generally, best application method of humic or fulvic acids was soil added with foliar compared with foliar or soil added alone. The effects of humic acid on plant growth were reported by Fortun *et al.,* (1989) who cleared that, fulvic acid result in stronger and more rapid soil-binding mechanism than humic acid (within two weeks) which requires longer time for soil contact because when it is adsorbed on mineral colloids it forms complexes very slowly.

It is evident from the data in Table 5, that all minerals content N, P and K % content in shoot and fruit of cucumber under investigation were gradually increased by increasing humic or fulvic acids rates. According to the results, C4 addition at a rate of 15 L fed^{-1} added as soil application combined with foliar one at a rate of 150 ppm from humic or fulvic acids, generally, had the positive and significant effects on cucumber yield. The increase in nitrogen content of shoots and fruit of cucumber plants, due to humic and fulvic acid application might have influenced plant growth directly through its effects on ion uptake or by the effects on plant growth regulators. These results were in line with those obtained by Rauthan and Schnitzer (1981) and Atiyeh, *et al,.* (2002). These increments led to positive effect on growth parameters of tomato and cucumber and increased nitrogen and phosphorus percent.

In addition, humic acid more effective on availability for the nutrients in the soil. Türkmen *et al,.* (2004) similarly reported that 1000 g kg^{-1} of HA application positively affected plant growth under saline soil conditions, but higher doses of HA inhibited plant growth. The need to exploit the capacity of plant leaves to absorb inorganic nutrients has increased greatly for a number of reasons (i) adverse soil conditions which favour fixation of nutrients and thus render many essential ones unavailable for root absorption; (ii) root absorption is slow for some elements and also results in poor translocation; (iii) relatively large amounts of fertilizers are required for root supply and heavy application loads to soil-water pollution. Foliar supply of nutrients can result in increasing the photosynthetic efficiency and it is possible to modify the physiology of leaf (Alam, 2006).

Scatter diagram Fig 1, show the regression and linear equations between additions rates from humic or fulvic on some physical properties i.e., bulk density, total porosity, moisture constants (field capacity, wilting point and available water), hydraulic conductivity and chemical properties i.e., pH, EC, organic matter and availability of N, P and K in clay loam soil. The previous equations illustrated that the correlation between levels application of humic and fulvic acids and bulk density, pH and electrical conductivity values (EC) were highly significance negative relationship but the correlation between levels application and field capacity, available water, total porosity, hydraulic conductivity, wilting point, organic matter and availability of N, P and K in clay loam soil were highly significance positive relationship.

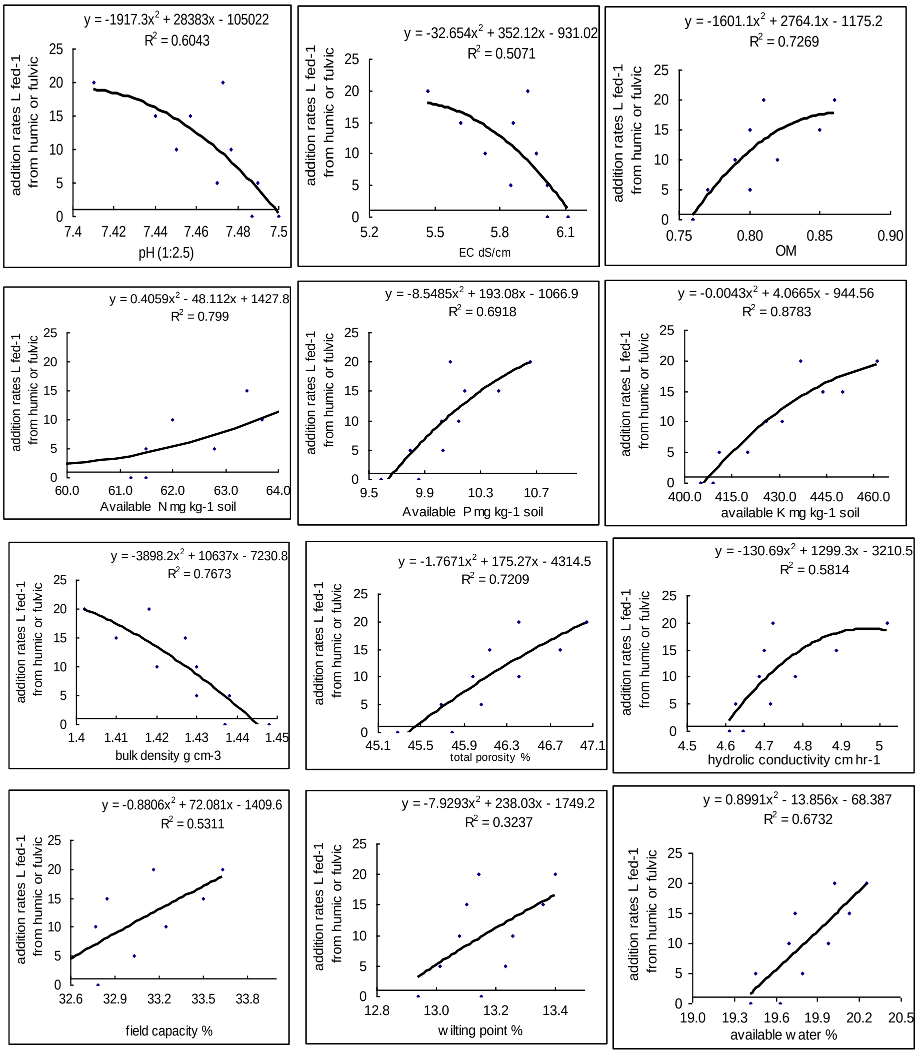

Fig. (1): Regression equations and effect of levels application of humic or fulvic on some chemical and physical soil properties.

Conclusion

The results of this study confirm and show that what might have been obtained under the conditions of active organic acids used, especially humic and fulvic acids, which improves the chemical and physical properties of soil and reflected positively on the productivity of different crops. The study also confirms the importance of studying the factors affecting soil properties of under conditions of production of plants protected through the use of drip irrigation, which led to the deterioration of these lands.

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تاثير إضافه أحماض الهيوميك والفولفيك علي خواص التربه الطبيعية والكيمائية وإنتاجية نبات الخيار تحت ظروف الزراعة المحمية.

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مركز البحوث الزراعية- معهد بحوث الأراضي والمياه والبيئة- جيزة- مصر

أجريت تجربة تحت ظروف الزراعه المحمية علي محصول الخيار المنزرع في تربة طينية طمبية في محطة البحوث الزراعية ببهتيم خلال موسم الشتاء 2010 لدراسة تأثير إضافة أحماض الهيوميك والفولفيك علي الخواص الطبيعية والكيميائية للتربة ومحصول الخيار، حيث أستخدمت تركيزات مختلفه منها أضيفت بطرق مختلفه إضافه أرضية بمعدلات (0، 5، 10، 15 ، 20 لتر/ فدان) وإضافه بالرش بمعدلات (0، 50، 100، 150، 200 ، جزء في المليون) كلا بمفردة مقارنة بالأضافة الأرضيه والرش معا) وقد تم دراسة تاثير تلك المعاملات على الخواص الطبيعية (الكثافة الظاهرة، المسامية الكلية، التوصيل الهيدروليكى، المحتوى الرطوبى عند السعة الحقلية، نقطة الذبول ، الماء الميسر ، والخواص الكيميائية (pH, OM, EC والميسر من النتروجين والفوسفور والبوتاسيوم.) .

أوضحت النتائج أن الإضافة المشتركه للأرضى والرش معا لكل من حامض الهيوميك والفلفيك كان لها تاثير إيجابي فى تحسين الخواص الطبيعية والكيميائية للتربه تحت الدراسة وخاصة عند إضافة الأحماض العضوية بمعدل 20 لتر / فدان للأرض و200 جزء فى المليون للرش يتبع ذلك الإضافة الأرضية ثم الرش كلا بمفردة.

كما أظهرت النتائج أن إضافة أحماض الهيوميك أو الفولفيك ذات تاثير إيجابي علي كل من محصول ثمار الخيار ، محتواها من الكربوهيدرات الكليه والذائبه ، و% للبروتين وكذلك محتوى الثمار والعرش من النيتروجين والفوسفور والبوتاسيوم . أيضا كانت أفضل طريقة إضافه لأحماض الهيوميك أو الفولفيك هي الإضافه الأرضية مع الرش علي الأوراق مقارنة مع الرش فقط أو الإضافه الأرضيه فقط. وتم الحصول على أعلى القيم من محصول الثمار ، ومحتواها من الكربوهيدرات الكليه أو الذائبة ، ومحتوها من البروتين و النيتروجين والفوسفور والبوتاسيوم عند معدل إضافه من حامض الهيوميك أو الفولفيك تصل إلي 15 لتر / فدان في حاله الإضافه الارضية ، 150 جزء في المليون عند الإضافة بالرش علي المجموع الخضري .

هذه النتائج تؤكد أن ما قد تم الحصول عليه في ظل ظروف هذه الدراسة أن إستخدام الأحماض العضوية يحسن من خصائص التربة الكيميائية والفيزيائية مما ينعكس إيجابا على المحاصيل وتؤكد الدراسة أيضا على أهمية دراسة العوامل التي يمكن أن تحسن خصائص التربة الفيزيائية والكيميائية السيئة للأراضي التي يتم إستخدامها تحت ظروف انتاج النباتات المحمية من خلال استخدام الري بالتنقيط الذي أدى إلى تدهور هذه الأراضي.

قام بتحكيم البحث

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