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Effect of Humic Acid and Amino Acids Rates on Growth, Yield and Nutritional Status of Okra Plants Grown in Sandy Soil

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Abstract: The study aimed to combine two types of organic fertilizers, one of which (humic acid) is added with fertigation system and the other (amino acid) is sprayed on plant leaves to avoid losing nutrients by leaching from the soil surface as the soil is sandy. To achieve this purpose in field, two field experiments were conducted during the winter seasons of 2021 and 2022 at Experimental Station of the National Research Centre in El-Nobaria region, Behira Governorate, North Egypt. Three rates of humic acid were added (0, 5 and 10 g l^{-1}) as soil drenched combined with spraying three concentrations of amino acids (0, 0.5 and 1 g l^{-1}). Treatments were added three times (20, 35 and 50 days after planting). Standard agricultural practices for okra production were carried out according to the recommendations of the Egyptian Ministry of Agriculture. The design of the experiments was split plot with three replications. Results revealed that the single application of either humic or amino acid increased pod dry mass and total yield of plant pods the increment was enhanced by their combining. Whereas, single application of humic acid has no effect on growth parameter (Stem and pod length, number of levees and branches, bod diameters, dry mass of shoot and root and shoot to root. Single application of amino acid increased all growth parameters in except stem length and pod diameter. Also, combining amino acid with Humic enhanced the effect of Humic on all growth parameters. shoot to root ratio was influenced by amino acid only where foliar application of amino acid reduced this ratio this might be attributed to role of amnio acid in increasing the export of sugar from sources organ to the roots and thus improving their growth. Single application either humic or amino acid increased N, Zn and Mn content in plant pods and had no effect on K content in plant pod, meanwhile, P content in pods was not affected by foliar application of amino acid, their combing enhanced nutritional values in pods of okra plants. These results proved that foliar application of amnio acidsboostedutilizationof humicacids.

Key words: Humic acid · Amino acids · Okra plant · Growth · Yield · Nutritional status

INTRODUCTION

The soils in new reclaimed regions are often sandy. The main problem obvious in the sandy soils is its very limited fertility which leads to consumed huge quantity of inorganic fertilizers; most of these fertilizers are lost by leaching from the surface of the soil. This is one of the constraints in this region limit agricultural production. Increasing the cation exchange capacity of sandy soil is a biggest challenge that can be solve by adding organic substances to the soil, where humic acid is one of these substances.

Humic acid is the largest component of humic substances. Humic acids are formative out of the chemical and biological humification of plant and animal matter and through the biological vigor of microorganisms [1]. Humic acid iscolloidal, amorphous and polydisperse organic compound with complex compositions and structures [2] and it is composed of various molecular moieties andfunctional groups [3]. Extensive studies have demonstrated that humic acid plays an important role in the stimulation of plant growth, improvement of nutrient content [4, 5, 6, 7]. The effects of humic acids on plant growth hinge on the origin and condensation. Lower

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molecular size fraction easily reaches the plasma lemma of plant cells, limiting an affirmative effect on plant growth, as well as ultimate effect at the level of plasma membrane and nutrient uptake. Upshots seen on the middle metabolism were low comprehends; however, it imitates those humic acids may leverage both respiration and photosynthesis [8].

Another strategy is to provide plants with nutrients via leaves instead of the roots to avoid losing of such as nitrogen particularly in nitrate form which is susceptible to leaching from soil surface.

Amino acids are organic chemical compounds and are the building blocks of proteins, which perform structural, metabolic and transport functions in plants [9]. Amino acids improve the efficiency of the plant's metabolism to induce yield increases, increasing plant tolerance to abiotic stresses, facilitating nutrient assimilation, translocation and use [10], promoting the processes of plant respiration, photosynthesis, protein synthesis, strengthening plant growth and yield formation [11].

Okra (*Abelmoschus esculentus* L.) is one of the summer vegetable crops grown in Egypt in order to obtain green pods. Okra is a common nutritious food and is rich in vitamin C. Okra is also used as a treatment and fight against the papilloma virus [12].

The study aimed to evaluate single and combining application of humic and amino acidsand their effects on growth, yield and nutritional status of okra plants grown in sandy soil.

MATERIALS AND METHODS

This study was conducted in the Experimental Station of the National Research Centre in El-Nobaria region, Behira Governorate, North Egypt, during the two successive seasons of 2021 and 2022. This work aimed to study the effect of humic acid and amino acids on growth, yield and nutritional status of okra plants (*Abelmoschus esculentus* L. Dwarf green cv.). Some physical and chemical properties of the soil used in the experiments are shown in Table (1) using the standard procedures outlined by Cottenie [13].

Okra seeds were sown on 16^{th} of January 2021 and 2022 seasons under drip irrigation system with all agricultural managements required for crop production as usually recommended. Three rates of humic acid were added (0, 5 and 10 g l^{-1}) as soil drenched simultaneously with spraying three concentrations of amino acids (0, 500 and 1000 mg l^{-1}). Treatments were added- three times (20, 35 and 50 days after planting). Standard agricultural practices for okra production were carried out according to the recommendations of the Egyptian Ministry of Agriculture. The design of the experiments was split plot with three replications. Humic acid rates were in the main plots and amino acids concentrations were in the sub plots.The chemical analysis of humic acid is shown in Table (2).

Three plants were chosen at random from every plot at 75 days after planting to study the following parameters. The following data were recorded:

Table 1: Some physical and chemical properties of the soil used

Particle size distribution %				
Sand	Silt	Clay	Texture	$CaCO_3$ %
92.65	5.07	2.28	Sandy	1.9
Soluble ions (mmol L^{-1})				Saturation %
Ca^{++}	Mg^{++}	Na^+	K^+	
8.02	3.23	3.92	0.91	22.5
$CO_3^{=}$	HCO_3^-	Cl^-	$SO_4^{=}$	Organic matter%
nd	2.2	3.98	9.9	0.15
Available nutrient (mg kg^{-1} soil)			EC (dS m^{-1})	pH
N	P	K		
24.5	2.9	56.4	1.6	7.7

Table 2: Chemical analysis of humic acid used

			N	P	K	Fe	Zn	Mn
pH	EC (dS m^{-1})	Organic mater (%)	%			mg kg^{-1}		
7.80	0.82	64	1.99	0.15	6.00	415	236	124

Vegetative Growth: Plant height, number of leaves per plant, number of branches and dry weight shoot and root per plant.

Yield: Pod length, pod diameter, pods weight plant^{-1} and total yield was calculated as ton fed^{-1} at 90 days after planting.

Nutritional Status: The percentage of N, P and K in leaves were determined according to the methods in [13]. Concentrations of Fe, Zn and Mn were determined using atomic absorption spectrophotometer using the method of A.O.A.C. [14].

Statistical Analysis: All data were subjected to statistical analysis using Mstatc software. The comparison among means of the different treatments was determined, as illustrated by Snedecor and Cochran [15]. Means of the treatments were compared by the Least Significant Differences Test at (0.05) level of significance.

RESULTS AND DISCUSSION

The use of organic fertilizers in sandy soil to reduce nutrient losing by leaching as well as application of slow-release management to ensure its sustainability and availability to the plant is the biggest challenge to face. Factorial experiment was conducted on sandy soil and aimed to reduce leached nutrients by: first factor was ground supplying of chelated nutrient on humic acid. Second factor was foliar application of N in form of amino acid to avoid N leaching. Results indicated that humic acid and foliar application of amino acid and their combination had significant effect on growth parameters, yield and nutrient content in pods of okra plants (Table 3, 4, 5).

In absent of amino acid, using humic acid had no significant effect on stem length number of leaves and branches and plant shoots and roots. Also, stem length and number of branches of okra plants were not affected by foliar application of amino acid with eliminating humic application (Table 3). Number of leaves was increased by amino acid where; application of 0.5 g L^{-1} was enough. Plant shoot and root biomass increased and recorded the highest value at foliar application of 1 g L^{-1} amino acids (Table 3).

With respect to the interaction between the two factors (humic acid and amino acids), both factors affected each other. Humic acid showed the effect on amino acid treatments, where, using 5 or 10 g L^{-1} humic acid promote plant response to foliar application of amino acid by expanding stem length. Although humic and amino acid combination increased shoot, root biomass, the interaction between humic and amino acid was not existed. Whereas, number of leaves and branches were not influenced by humic and amino acid combination. Shoot to root ratio was reduced by foliar application of amino acid, humic acid and the interaction between humic and amino acids treatments had no significant effect on shoot to root ratio. these findings illustrate that spraying 1 g L^{-1} amino acid on plant leaves improved root growth more than leaves growth during vegetative growth phase (Table 3).

Explain the improvement and promotion of plant growth by amino acids by increasing plant cell division and improving the optimal absorption of water and nutrients, which are important for the life of plants [16]. Also, amino acids stimulate plant growth by the assimilation of enzyme activation, protein synthesis and the activation of biomass production [17]. Amino acids can regulate hormone levels inside plants. Foliar application of amino acid provides precursor to indols that can improve vegetative growth [18]. Humic acid improves plant growth indirectly as a result of improving the natural properties of the soil, as it enhances the formation of agglomerates and the moisture properties of the soil [19]. Humic acid also enhances the chemical properties of the soil by improving the soil pH and reducing the effect of high salinity. It also enhances the availability of nutrients in the soil, which facilitates their absorption by plant roots [20]. Abd El-Rheem *et al*. [21] reported that spraying potato plants with humic acid (2 ml L^{-1} and amino acids (1000 ppm) resulted in improved plant growth of potato plants compared to the treatment in which the plants were not sprayed with either and this during the two growing seasons.

Addition of humic to the soil complemented by foliar application of amino acid had significant effect on okra plants. application of humic acid or amino acid had no effect on pod length, pod diameter and total yield of okra plants, meanwhile, mean pod biomass increased gradually with increasing rate of humic or amino acid up to 10 or 1 g L^{-1} respectively.

Regarding the interaction between humic acid and amino acid application, both factors affected each other. Humic acid showed the effect on amino acids treatments where, using 5 or 10 g L^{-1} from humic acid solution increased pod length and pod biomass and total pods

Table 3: Effect of different rates of humic acid and amino acid on vegetative growth of okra plants at two seasons

Treatment					Dry weight (g plant^{-1})		
Humic acid (g l^{-1})	Amino acids (g l^{-1})	Stem length cm	No. of leaves	No. of branches	Shoot	Root	Shoot: root ratio
			First season				
0	0.0	58	15	2.1	38	4.0	9.5
	0.5	60	18	2.3	40	4.4	9.1
	1.0	61	18	2.3	42	5.2	8.1
5	0.0	59	16	2.2	39	4.1	9.5
	0.5	64	18	2.3	44	4.6	9.6
	1.0	70	19	2.4	47	5.9	8.0
10	0.0	60	16	2.3	40	4.2	9.5
	0.5	67	19	2.3	47	5.1	9.2
	1.0	74	19	2.4	51	5.7	8.9
$LSD_{0.05}$		6	1	0.1	2	0.1	0.2
			Second season				
0	0.0	58	15	2.2	38	3.9	9, 7
	0.5	61	18	2.3	40	4.4	9.1
	1.0	64	19	2.3	43	5.3	8.1
5	0.0	59	16	2.3	39	4.1	9.5
	0.5	66	18	2.4	46	4.8	9.6
	1.0	72	20	2.4	47	5.9	8.0
10	0.0	60	16	2.4	39	4.4	8.9
	0.5	68	19	2.4	47	5.2	9.0
	1.0	74	20	2.5	51	5.9	8.6
$LSD_{0.05}$		6	1	0.1	2	0.1	0.2

Table 4: Effect of different rates of humic acid and amino acid on yield of okra plants at two seasons

Treatment					
Humic acid (g l^{-1})	Amino acids (g l^{-1})	Pod length (cm)	Pod diameter (cm)	Pods weight plant^{-1} (g)	Total yield (ton fed^{-1})
			First season		
0	0.0	1.50	2.66	225	2.34
	0.5	1.64	2.81	241	2.48
	1.0	1.76	2.90	265	2.56
5	0.0	1.55	3.05	235	2.41
	0.5	1.81	3.12	283	2.89
	1.0	1.98	3.23	300	3.08
10	0.0	1.60	3.10	250	2.95
	0.5	2.11	3.33	312	3.12
	1.0	2.13	3.44	323	3.24
$LSD_{0.05}$		0.15	0.71	20	0.91
			Second season		
0	0.0	1.51	2.69	225	2.35
	0.5	1.65	2.81	241	2.50
	1.0	1.78	2.93	266	2.61
5	0.0	1.58	3.00	237	2.42
	0.5	1.82	3.14	283	2.91
	1.0	1.97	3.29	302	3.07
10	0.0	1.62	3.12	251	2.98
	0.5	2.10	3.32	315	3.15
	1.0	2.15	3.45	326	3.28
$LSD_{0.05}$		0.14	0.70	26	0.90

Table 5: Effect of different rates of humic acid and amino acids on nutrients content of okra pods at two seasons

Treatment		N	P	K	Fe	Zn	Mn
Humic acid ($g\ l^{-1}$)	Amino acids ($g\ l^{-1}$)	%			mgl^{-1}		
				First season			
0	0.0	0.57	0.23	0.89	128	34	41
	0.5	0.65	0.24	0.89	134	37	43
	1.0	0.67	0.23	0.89	134	37	44
5	0.0	0.60	0.30	0.90	136	35	46
	0.5	0.77	0.33	0.93	145	38	47
	1.0	0.79	0.37	0.96	149	38	49
10	0.0	0.64	0.31	0.91	142	40	47
	0.5	0.81	0.37	0.97	153	44	45
	1.0	0.83	0.32	0.98	153	47	48
$LSD_{0.05}$		0.04	0.02	0.03	68	2	2
				Second season			
0	0.0	0.58	0.23	0.88	130	35	41
	0.5	0.66	0.23	0.89	135	36	44
	1.0	0.70	0.24	0.89	135	37	45
5	0.0	0.62	0.30	0.90	142	35	46
	0.5	0.79	0.34	0.94	145	39	48
	1.0	0.80	0.34	0.95	141	38	48
10	0.0	0.64	0.31	0.91	151	41	46
	0.5	0.81	0.37	0.97	152	46	48
	1.0	0.84	0.38	0.98	153	48	49
$LSD_{0.05}$		0.04	0.02	0.03	71	2	2

yield of amino acids-supplied plants particularly that received 1 g L^{-1} form amino acids and 10 g L^{-1} from humic acid solution (Table 4). Despite of the combination between ground humic application and foliar application of amino acids provided high value of pod diameter and total pods yield, these incrementsremain no significant due to the large range of experimental error (Table 4).

El-Ghamry *et al*. [22] studied the effect of humic acid and amino acids applications on faba bean plants. They found that humic acid (2000 ppm) interacted with amino acid (2000 ppm) significantly increased number of pods/ plant and weight of 100 seeds.EL-Tanahy *et al*. [23] application of humic acid on okra plants treated with high application of humic at high level (10%) which had the best yield parameters including pod length, pod diameters and total yield. Abd El-Rheem *et al*. [21] showed that the best treatment which given high value of growth and yield of potato when spraying with highest level of humic acid and amino acids. As spraying with humic acid at the rate of 2 ml L^{-1} with amino acid at the rate of 1000 ppm led to an increase in the plants height by 25.5%, the tuber diameter by 42.6 % and the total yield by35.9%, compared to not spraying them.

Using humic acid only resulted in increased N and Zn concentration in plant pods. The increment in nitrogen concentration is gradual depending on the concentration of humic but the increase in zinc concentration was found only when humic was added at the rate of 10 g L^{-1}. In comparison to control, using humic at rate 5 and 10 g L^{-1} were associated with higher P and Mn concentration in okra pods, whereas, K content in pods of okra plants were no affected by humic supply.

Foliar application of amino acid had significant effect on nutrient contents in pods of okra plants, spraying amino acid at the rate 0.5 g L^{-1} is satisfactory because the increment of nutrient contents in plant pods resulted from using amino acid at rate 1 g L^{-1} is not significant as compared with using it at rate 0.5 g L^{-1} (Table 5).

Using amino acid resulted in increased N, Zn and Mn content in plant pods this finding indicates that Mn and particularly Zn require amino acid as carrier for their exporting from source organ (leaves) to sink organ (pod). It is well known that Mn and zinc remobilization needs adequate amount of N supply particularly in form of amino acid. Also, humic acid had the same effect on Zn that meanshumic acid reach by N which could be converted amino acid to remobilize Zn from leaves to pods. Amino acid had no impact on P and K content in plant pods. These results are identical in both seasons (Table 5).

With respect to the interaction effect on each other, using humic had an effect on the plant's response to foliar application of amino acid. P and K content in pods were influenced by amino acid application when these plants supplied humic acid these findings refer to humic acid reach by P and K and spraying amino acid assisted plant to remobilized P and K to pods. Whereas, N, Zn and Mn content in pods were not affected by impact humic on amino acid application but nutrient content (N, Zn and Mn) in pods were influnced by impact amino acid on humic application (Table 5). There were no significant differences between second (5 g L^{-1}) and third (10 g L^{-1}) level of humic application. Therefore, using humic at the third (10 g L^{-1}) level is uneconomical and it must be satisfied with the second level (5 g l^{-1}).

Ibrahim *et al*. [24] reported that humic acids had beneficial effects on nutrients uptake by plants. Hypotheses which account for the stimulatory effects of humic acid are numerous, the most convincing of which is a 'direct' action on the plant, which is hormonal in nature, together with an "indirect action" on the metabolism of microorganisms and the dynamics of uptake of soil nutrients. Zaghloul *et al*. [25] found that application of humic acid led to increase N, P, K, Fe, Zn and Mncontent in the plant due to increasing absorption and transfer of nutrients in plants by enhancing metabolism. So, humic acid makes positive effects on physiological processes including photosynthesis and facilitating the transfer of materials within the plant can improve the grain growth. Abo Sedera *et al*. [26] indicated that spraying strawberry plants with amino acids at 1000 mg L^{-1} significantly increased total N, P, K, Fe, Zn and Mn in plant foliage compared with control treatment.

CONCLUSION

Using of humic acid led to an improvement in the growth, yield and nutritional status of okra plants and the effect was more significant when the plants were sprayed with amino acids. The best treatment which given high value of growth and yield parameters and nutrients content when spraying the highest spray concentration of amino acids (1000 mg l^{-1}) with the highest rate addition of humic acid (10 g l^{-1}).

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