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Responses of Eggplant (*Solanum melongena var. esculenta* L) Plants to Different Foliar Concentrations of Some Bio-Stimulators

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ABSTRACT

Fertilization is a major limiting factor for vegetable crops growth and productivity especially in the new areas. Therefore, this research aims to evaluate the effects of applying fertilizer in the stander form in comparison to different bio-stimulators on growth, yield and fruits quality of eggplant plants (*Solanum melongena var. esculenta L*) Egypt cv. "Black Balady". Field experiments were carried out during the two successive seasons of 2013 and 2014 in the Experimental Station of the National Research Centre in El-Nobaria region, Behira Governorate, North Egypt, to study the effect of foliar application of different bio-stimulators, Stimufol at rates of 1, 2 and 4 g/L, Humic acid at rates of 2, 4 and 6 cm/L, Active dry yeast at rates of 1, 2 and 4 g/L and amino acid compound at 2, 4 and 8 cm/L compared to spraying with tap water "control treatment". Data showed that all morphological characters parameters of eggplant plants (plant length, number of leaves and number of branches and fresh and dry weight of leaves per plant) were improved by using all different of bio-stimulators treatments compared to non-treated plants (control). Yield and its components of eggplant plants followed also the same trend. The high concentration of yeast (4 g/L) treatment recorded the highest compared to yeast at 1 g/L and 2 g/L except for fresh and dry weight of leaves significant effect on vegetative growth of eggplant plants. While, results indicated that the highest yield and its components were recorded by amino acid 8 cm/L treatment compared to other treatments.

Key words: Eggplant, Bio-stimulators, Stimufol, Humic acid, Yeast, Amino acid, Foliar spray Vegetative growth, Total Yield, Quality and N, P, K.

Introduction

Eggplant (*Solanum melongena var. esculenta* L.), known as Aubergine, Brinjal or Guinea squash is one of the non-tuberous species of the night shade family Solanaceae (Kantharajah and Golegaonkar, 2004). Eggplant fruits contain a considerable amount of carbohydrates, proteins and some minerals (Rahman and Hoque, 1994 and Mahmoud, 2000). Eggplant fruits are known for being low in calories and having a mineral composition beneficial for human health. They are also a rich source of potassium, magnesium, calcium and iron (Zenia and Halina, 2008).

Humic acid is a commercial product of organic fertilizers containing most elements that improve soil fertility and increase nutrients availability, thus enhances plant growth and yield as well as decreases the harmful effect of stresses (Doran *et al*., 2003). Adani *et al.,* (1998) reported that humic acid is believed to increase nitrogen use efficiency and therefore stimulates the shoot and root growth. The humic substances are mostly used to remove or decrease the negative effects of chemical fertilizers from the soil and have a major effect on plant growth, (Ghabbour and Davies, 2001). Humic substances lead to a greater uptake of nutrients into the plant root and through the cell membrane (Yılmaz, 2007).

Humic acid constitute a stable fraction of carbon that improve some of the soil characteristics such as improve water holding capacity, pH buffering and thermal insulation (McDonnell *et al*., 2001). Humic acid assimilates minor and major elements, activates or inhibits enzyme, causes changes in membrane permeability resulting in protein synthesis and activating biomass production which stimulates plant growth (El-Ghamry *et al*., 2009). Humic acids (HAs) are the main fractions of humic substances (HS) and the most active components of soil and compost organic matter, HAs have been shown to stimulate plant growth and consequently yield by acting on mechanisms involved in: cell respiration, photosynthesis, protein synthesis, water and nutrient uptake, enzyme activities (Chen and Aviad, 1990; Concheri, 1994 and Chen, 2004).

Dry yeast is a natural bio-substance suggested to be of useful stimulatory, nutritional and protective functions when it is applied to vegetable plants during stress conditions due to its content of hormones, sugars, amino and nucleic acids, vitamins and minerals. Thereby, it can induce thermatolerance due to its role in the synthesis of protein and nucleic acids and in minimizing their degradation (Natio *et al.,* 1981).

Many investigations found that, application of dry yeast as a foliar spray was found to increase growth, yield and quality of some vegetable crops. (Fathy and Farid 2000) on some vegetable crops, (Abou El-Nasr *et*

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al., 2001) on squash, (Fathy *et al*., 2002 and Khedr and Farid 2002) on tomato plants, (Tarek 2003 and Mona *et al.,* 2005) on cucumber plant, (Sarhan, 2008) on potato and (Abou El-Yazied and Mady 2012) on broad bean. The dry bread yeast (*Saccharomyces cerevisiae*) is a kind of the used biofertilizers in soil fertilization or in foliar application on the shoots of vegetable crops (El-Ghamriny *et al.,* 1999). Also, many studies found that foliar application of yeast was found to increase growth, yield and quality of many vegetable crops (Gomaa *et al.,* 2005; Mona *et al*., 2005; El-Tohamy *et al.,* 2008; Fawzy, 2007; Hussain and Khalaf, 2007; Fawzy *et al.,* 2010 and Ghoname *et al.,* 2010).

Amino green compound contains organic acids plus amino acids 15% and some microelements such as iron, zinc and manganese. Micronutrients in amino green compound play a very important role in vital processes of plants. They improve photosynthesis which intensifies the assimilating activity of the whole plants (Marschner, 1995). Zinc in plants is involved in enzymatic relations. One of the most important functions of zinc show that starch synthesis is widely interrupted at zinc deficiency. It was also found that zinc plays an important role in protein synthesis from amino acids and in decarboxlation of pyruvate. Concerning iron, Derar *et al*., 1996 observed that using some materials containing Fe as a foliar spray significantly increased growth and yield of beans.

Amino acids are well known as bio-stimulants, which have positive effects on plant growth, yield and significantly mitigate the injuries caused by abiotic stresses (Kowalczyk and Zielony, 2008). The requirement of amino acids in essential quantities is well known as a means to increase yield and overall quality of corps (Slviero *et al.,* 2001; Attoa *et al.,* 2002; El- Shabasi *et al.,* 2005; Awad *et al.,* 2007; Fawzy, 2007; Al-Said and Kamal, 2008; Faten *et al.,* 2010; Fawzy *et al.,* 2010 and Shaheen *et al.,* 2010).

The aim of the present study was to investigate the effect of different levels of amino acid, stimufol, humic acid and active dry yeast (as foliar spraying) on the growth and productivity of eggplant plants under newly sandy soil conditions.

Material and Methods

The experiments were carried during the two successive growing seasons of 2013 and 2014 at the experimental station of National Research Centre in Nobaria (Behira Governorate) Egypt. Eggplant (cv. "Black Balady") transplanted when reached 50 days old in the field on 5 April and 10 April in first and second seasons, respectively. Seedlings of eggplant were planted on ridges of 70 cm width and 10 m length and 50 cm apart. Each plot included 4 ridges and the plot area was 20 m^2. Normal agricultural practices common in the area were followed.

This study aimed to investigate the effect of foliar application of Stimufol "NPK plus trace elements" at rates of 1, 2 and 4 g/L, Humic acid at rates of 2, 4 and 6 cm/L, Active dry yeast at rates of 1, 2 and 4 g/L and Amino acid compound at 2, 4 and 8 cm/L compared to spraying with tap water "control treatment" on growth, yield and fruits quality of eggplant (*Solanum melongena var. esculenta L*). All treatments were sprayed at flowering stage, twice with 10 days intervals. The experiments were arranged in randomized block design with three replicates. Four plants of each plot were chosen randomly at 75 days after transplanting. All agricultural practices for eggplant production in the growing area were applied as recommended by Ministry of Agriculture. The Physical properties and chemical analysis of the experimental soil are presented in Table (1).

Table 1: Physical properties and chemical analysis of the experimental soil.

Physical properties								
Sand	Clay	Silt	Texture	F.C.%	W.P.%			
90.08	9.14	0.62	Sandy	16.11	5.09			
Chemical analysis								
E.C. M/moh	pH	Meq./L						
		Ca	Mg	Na	K	HCO_3	Cl	
1.6	8.0	7.0	0.511	0.944	0.299	1.22	0.532	

The chemical compositions of foliar application substances:

The compositions of stimufol fertilizer were 25% nitrogen, 16% phosphorus, 12% potassium, 0.20% magnesium, 0.044% boron, 0.17% iron, 0.03% zinc, 0.08% manganese, 0.001% molybdenum, 0.081% copper and 0.01% cobalt.

The chemical composition of soluble potassium humate were 80% humic acid (25.0 g/L, Folic acid 0.7 g/L, nitrogen 4.0 g/L, phosphorus 0.6 g/L and potassium 8.0 g/L), 11-13% K2O, 5-7% moisture, 83 g/100ml bulk density, > 98 % water solubility.

On the other hand, regarding the chemical analysis of the dry yeast, N.R.P (1977) stated that, the analysis of dry yeast was protein (47.2%), arginine (2.6%), glycin (2.6%), histidin (1.4%), islysine (2.9%), lauicine (3.5%), Lysine (3.8%), methionine systine (0.6%), phnyl-alanine (3%), tyrosine (2.1%), threonine (2.6%), tryptophan (0.5%) and vitamin B (2.9%). Goyal and Khuller (1992), Yatskovskaya *et al.,* (1992), Murakami *et*

al., (1996) and Khedr and Farid (2002) reported that, yeast preparation contained carbohydrates, sugars, proteins, fatty acids, amino acids, hormones, macro and micro elements in suitable balance.

Amino green compound contains (w/v) total organic acids plus amino acids 15%, iron (Fe) 2.9%, zinc (Zn) 1.4% and manganese (Mn) 0.7%, free amino acids, proline, hydroxy proline, glycine, alanine, valine, methionine, escaliosin, lysine, cycteine, phenylalanine, serine, glutamic, arginine, histidine, lysine and hystiden.

The following data were recorded:
Vegetative growth:

A random sample of 4 plants from each plot was taken at 75 days after transplanting. All vegetative growth parameters i.e., plant length (cm), number of leaves/plant, number of branches/plant, fresh weight of leaves/plant (g) and dry weight of leaves/plant (g) were measured.

Yield and fruit quality:

At harvest stage the mature fruits of eggplant were harvested twice every week along the harvesting season. At harvest time the fruit length (cm), fruit diameter (cm), average fruit weight and fruit yield (kg/m^2) of each plot were recorded and the total yield as ton/fed. was calculated.

Chemical constituents:

Samples of leaves were oven dried at 70 C then fine grinded and wet digested. N, P and K contents of leaves were determined according to the methods mentioned by Black (1983), Troug and Mayer (1939) and Brown and Lilleland (1946), respectively.

The experimental design was arranged in randomized block design with three replicates. Data collected were subjected to statistical analysis according to the method described by Gomez and Gomez (1984).

Results and Discussion

Effect of bio-stimulators on morphological characters of eggplant plants:

Results in Table (2) showed the effect of bio-stimulators (stimufol, humic acid, yeast and amino acid) levels on morphological characters of eggplant plants. Increasing yeast concentration (4 g/L) resulted in an increase in plant length, number of leaves and number of branches compared to other treatments (1 and 2 g/L).

Table 2: Morphological characters of eggplant plants as affected by stimufol, humic acid, yeast and amino acid levels.

Treatments		Plant length (cm)	Number of leaves	Number of branches	Fresh weight of leaves (g/plant)	Dry weight of leaves (g/plant)
		First season				
Control		44.20	52.34	3.00	135.71	21.20
Stimufol	1 g/L	49.10	57.65	4.77	210.65	32.49
	2 g/L	52.70	64.33	6.22	269.57	42.38
	4 g/L	52.00	62.66	5.00	236.77	37.39
Humic acid	2 cm/L	53.40	66.44	6.00	221.99	36.36
	4 cm/L	57.90	71.88	7.85	281.47	46.51
	6 cm/L	55.10	68.66	7.00	247.21	40.92
Yeast	1 g/L	61.30	72.11	6.88	330.67	51.70
	2 g/L	70.90	77.88	7.52	300.11	45.02
	4 g/L	75.20	80.66	8.84	290.66	42.99
Amino acid	2 cm/L	94.20	89.66	9.93	291.98	48.56
	4 cm/L	85.10	87.00	8.22	315.33	53.71
	8 cm/L	79.80	81.11	7.63	357.69	64.50
L. S. D. at 5%		8.94	5.13	1.67	35.18	7.59
		Second season				
Control		43.04	52.32	2.92	142.97	20.71
Stimufol	1 g/L	48.87	58.64	4.66	202.15	34.14
	2 g/L	53.15	66.59	6.38	272.27	42.91
	4 g/L	52.32	64.61	4.93	233.24	38.27
Humic acid	2 cm/L	53.99	69.10	6.12	225.65	37.05
	4 cm/L	59.34	75.58	8.32	286.43	49.13
	6 cm/L	56.01	71.75	7.31	245.66	42.47
Yeast	1 g/L	63.39	75.85	7.17	334.98	51.31
	2 g/L	74.81	79.72	7.93	308.61	47.35
	4 g/L	75.93	83.03	9.50	297.37	44.93
Amino acid	2 cm/L	93.54	89.74	10.31	298.94	48.57
	4 cm/L	91.71	88.57	8.76	316.72	53.69
	8 cm/L	85.40	86.56	8.06	367.13	65.53
L. S. D. at 5%		9.08	4.86	1.97	26.66	6.81

On the contrary, the highest value of fresh and dry weight of leaves per plant was recorded with the lowest concentration (1 g/L) in both seasons. This increment was statistically significant in both seasons. These results are consistent with the previous findings of Gomaa *et al.,* (2005); Mona *et al*., (2005); El-Tohamy *et al.,* (2008); Fawzy, (2007); Hussain and Khalaf, (2007); Fawzy *et al.,* (2010) and Ghoname *et al.,* (2010). They found positive effects of yeast on plant growth of eggplant, tomato, cucumber and other plants. The results also indicated an increase in morphological characters at stimufol (2 g/L), humic acid (4 cm/L) and amino acid (2 cm/L) treatments in comparison with the rest of concentrations to all treatments. These results were statistically significant in both seasons. Generally, the results in Table (2) indicated that the use the bio-stimulators (stimufol, humic acid, yeast and amino acid) increased all morphological characters in comparison with control treatment. Similar results were obtained by Doran *et al*., (2003); Yılmaz, (2007); Kowalczyk and Zielony, (2008) and El-Ghamry *et al*., (2009). They reported that bio-stimulants have positive effects on plant growth and significantly mitigate the injuries caused by abiotic stresses.

Effect of bio-stimulators on yield and its components of eggplant plants:

Data in Table (3) showed the effect of different levels of bio-stimulators (stimufol, humic acid, yeast and amino acid) on yield and its components of eggplant plants. The different levels of amino acid treatments had a significant effect on yield and its components of eggplant plants compared to other treatments. Increasing amino acid levels from 2 cm/L up to 8 cm/L increased fruit length, fruit diameter, average fruit weight, fruit yield (kg/m^2) and total yield (ton/fed.).

Table 3: Yield and components of eggplant plants as affected by stimufol, humic acid, yeast and amino acid levels.

Treatments		Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (g)	Fruit yield (kg/m^2)	Total yield (ton/fed.)
		First season				
Control		9.68	2.84	43.33	1.53	6.11
Stimufol	1 g/L	11.13	3.00	47.65	1.64	6.55
	2 g/L	12.45	3.47	50.99	1.92	7.67
	4 g/L	11.88	3.16	48.48	1.75	7.00
Humic acid	2 cm/L	12.69	3.25	51.68	1.71	6.84
	4 cm/L	13.47	4.00	53.88	1.98	7.92
	6 cm/L	13.00	3.87	52.00	1.86	7.44
Yeast	1 g/L	14.66	4.36	63.54	1.94	7.76
	2 g/L	14.00	4.05	60.00	2.15	8.60
	4 g/L	13.23	3.66	58.99	2.00	8.00
Amino acid	2 cm/L	13.23	4.44	65.49	2.33	9.33
	4 cm/L	14.71	4.86	68.68	2.53	10.11
	8 cm/L	17.90	5.11	73.81	2.69	10.77
L. S. D. at 5%		1.07	NS	4.83	0.17	0.47
		Second season				
Control		9.54	2.79	43.04	1.40	5.75
Stimufol	1 g/L	10.72	2.98	47.18	1.53	6.27
	2 g/L	12.53	3.54	51.16	1.86	7.61
	4 g/L	11.62	3.17	48.17	1.66	6.81
Humic acid	2 cm/L	12.58	3.28	51.98	1.66	6.62
	4 cm/L	13.51	4.07	54.60	1.99	7.90
	6 cm/L	12.95	3.92	52.36	1.84	7.33
Yeast	1 g/L	14.93	4.35	66.09	1.94	7.71
	2 g/L	14.14	4.13	61.88	2.19	8.71
	4 g/L	13.22	3.67	60.68	2.01	8.04
Amino acid	2 cm/L	13.75	4.59	65.41	2.41	9.58
	4 cm/L	14.98	4.92	68.21	2.64	10.51
	8 cm/L	15.21	5.06	74.31	2.73	10.52
L. S. D. at 5%		NS	NS	4.77	0.11	0.96

Meanwhile, the highest yield and its components were recorded by amino acid 8 cm/L and 4 cm/L, while the lowest values were obtained by using 2 cm/L. All these increments were statistically significant in both seasons. The obtained results are supported by those of Slviero *et al.,* (2001); Attoa *et al.,* (2002); El- Shabasi *et al.,* (2005); Fawzy *et al.,* (2010) and Shaheen *et al.,* (2010). They indicated that the requirement of amino acids in essential quantities is well known as a means to increase yield and overall quality of corps. It is clear from Table (3) that yield and its components of eggplant plants increased with stimufol (2 g/L), humic acid (4 cm/L) and yeast (1 g/L) treatments while the higher values of fruit yield (kg/m^2) and total yield (ton/fed.) were recorded with yeast (2 g/L) treatment compared to 1 g/L and 4 g/L of yeast. These results were agreed with previous studies that were done on the effect of bio-stimulators on some vegetable crops by Chen and Aviad, (1990); Concheri, (1994); Chen, (2004). They found that humic acid stimulated plant growth and consequently yield by

acting on mechanisms involved in: cell respiration, photosynthesis, protein synthesis, water and nutrient uptake, enzyme activities. Also, similar results were reported by Fathy *et al* (2002); Tarek (2003); Mona *et al,* (2005); Sarhan (2008) and Abou El-Yazied and Mady (2012). They found that application of yeast and bio-stimulators led to increase growth, yield and quality of some vegetable crops. Also the results showed that control treatment had the lowest values in comparison with other treatments. All these results were statistically significant in both seasons.

Effect of bio-stimulators on Chemicals contents of eggplant plants:

The effects of different levels of bio-stimulators (stimufol, humic acid, yeast and amino acid) on N, P and K contents in leaves of eggplant plants are shown in Table (4). Results showed that total chemical of N, P and K increased with increasing the amount of amino acid level (8 cm/L), while the lowest values recorded with amino acid level (4 cm/L and 2 cm/L) respectively. This increment was statistically significant in both seasons except for P percentage in leaves. The results indicated the increase in chemical contents at stimufol (2 g/L), humic acid (4 cm/L) and yeast (2 cm/L) treatments in comparison with the other of concentrations to all treatments. On the contrary, the lowest chemical contents were recorded with control treatment. The obtained results are supported by Natio *et al,* (1981); Marschner, (1995); Derar *et al*., (1996); Adani *et al.,* (1998); Ghabbour and Davies, (2001); McDonnell *et al*., (2001); Yılmaz, (2007) and Kowalczyk and Zielony, (2008). They reported that bio-stimulators are believed to increase nitrogen use efficiency and therefore stimulates the shoot and root growth. Also, they found that bio-stimulators substances are mostly used to remove or decrease the negative effects of chemical fertilizers from the soil and have a major effect on plant growth, bio-stimulators substances lead to a greater uptake of nutrients into the plant root and through the cell membrane.

Table 4: Chemicals contents of eggplant leaves as affected by stimufol, humic acid, yeast and amino acid levels.

Treatments		N (%)	P (%)	K (%)
		First season		
Control		2.07	0.30	1.62
Stimufol	1 g/L	2.24	0.32	1.66
	2 g/L	2.87	0.36	1.75
	4 g/L	2.41	0.33	1.70
Humic acid	2 cm/L	2.65	0.34	1.83
	4 cm/L	3.33	0.37	2.00
	6 cm/L	2.96	0.34	1.89
Yeast	1 g/L	3.47	0.36	2.45
	2 g/L	3.79	0.39	2.66
	4 g/L	3.56	0.38	2.52
Amino acid	2 cm/L	3.85	0.39	2.73
	4 cm/L	3.94	0.41	2.81
	8 cm/L	4.10	0.44	2.92
L. S. D. at 5%		0.09	NS	0.14
		Second season		
Control		1.94	0.25	1.56
Stimufol	1 g/L	2.15	0.27	1.61
	2 g/L	2.90	0.32	1.71
	4 g/L	2.35	0.28	1.65
Humic acid	2 cm/L	2.63	0.29	1.81
	4 cm/L	3.44	0.33	2.01
	6 cm/L	3.00	0.29	1.88
Yeast	1 g/L	3.61	0.32	2.43
	2 g/L	3.75	0.35	2.71
	4 g/L	3.72	0.34	2.63
Amino acid	2 cm/L	3.91	0.35	2.75
	4 cm/L	3.92	0.38	2.82
	8 cm/L	4.13	0.41	2.97
L. S. D. at 5%		0.14	NS	0.20

Conclusion

The results suggest to use bio-stimulators and environmentally safe and costless organic substances to encourage the productivity and quality of eggplant plants. It could be expected that the application of bio-stimulators can minimize the environmental pollution by reducing the use of synthetic fertilizers and chemicals in vegetable crops production.

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