ACTA AGROBOTANICA
Vol. 55, z. 2 – 2002
s. 81–88

Effects of different levels of humic acid on seedling growth and macro and micronutrient contents of tomato and eggplant

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(Received: 12.10.2001)

Summary

As opposed to direct sowing, production of seedlings of vegetable crops for transplanting is commonly practiced by vegetable growers. This study was undertaken to determine the effects of humic acid on the growth and the macro and micro nutrients contents in tomato *(Lycopersicon esculentum)* and eggplant *(Solanum melongena* var. *esculentum)* seedlings under greenhouse conditions. Different levels of humic acid (50, 100, 150, 200 ml l^{-1}) were applied to growing media (peat) after transplanting of examined seedlings of the species every ten days by the time of planting. The highest growth rate for leaf stem and root growth were obtained at 50 and 100 ml l^{-1} HA and 50, 100, 150 ml l^{-1} HA for tomato and eggplant seedlings, respectively as compared to the control. The highest content of macro and micronutrient contents were obtained at 100 ml l^{-1} HA and 200 ml l^{-1} HA for tomato and eggplant seedlings, respectively as compared to the control.

Key words: macro and micronutrient, tomato, eggplant, seedling growth, humic acid.

INTRODUCTION

Vegetable crops play an important role in the economy of all countries as vegetable production; processing and trading provide a livelihood for millions of people. The climate and geography favour the cultivation of wide range of vegetable crops and allows specialization in the production of economically important vegetables.

Production using transplanted seedlings of vegetable crops is an important method for vegetable growers. The environmental and soil conditions during the growth of vegetable seedlings in the nursery affect establishment and yield. One of the most important factors in obtaining quality seedlings is to optimise growth conditions (Nicola and Bassoccu, 1994).

Russo and Berlyn (1990) reported that humic substances (humic and fulvic acids) constitute 65–70% of the organic matter in soils. These compounds are the products of the decomposition of plant tissues, and these are predominantly derived from lignified cell walls. The major functional groups of humic acids include carboxyl, phenolic hydroxyl, alcoholic hydroxyl, ketone and quinoid . The mechanism of humic acid active in promoting plant growth is not completely known, but several explanations have been proposed by some authors (Vaugham, 1974; Cacco and Dell Agnolla, 1984; Russo and Berlyn, 1990) such as increasing cell membrane permeability, oxygen uptake, respiration and photosynthesis, phosphate uptake, root cell elongation of plant growth factors.

Tremblay and Senecal (1988), Melton and Daufault (1991) and Nicola and Bassoccu (1994) reported on vegetable seedling growth and its effect on yield in response to different fertilization levels in nursery.

Effects of fertilizers on yield, quality and nutrient content of some vegetables were also studied by Csizinszky (1986) on tomato, Csizinsky et al. (1990) on pepper and tomato, Güvenç and Padem (1995) on tomato, Böhme and Thi Lua (1997) on tomato, Aydin et al. (1999) on sunflower and corn and Dursun et al. (1999) on tomato and eggplant.

Böhme and Thi Lua (1997) reported that humic acids had beneficial effects on the nutrient uptake by plants, and they were particularly important to transport and availability of micro nutrients in plant.

On the other hand, improving soil conditions and establishing the equilibrium among plant nutrients are also important for soil productivity and plant production. For this purpose, in generally organic matter and similar materials were applied in soils, increasing agricultural production by improving soil physical, chemical and biological properties. Among these amendments many researches reported that humic acid increased availability of plant nutrients in soil and crop production by improving soil physical, chemical and microbiological properties (Jalali and Takkar, 1979; Foortun and Lopez-Fondo, 1982; Bowen et al., 1985; Sözüdogru et al., 1996).

The experiment was carried out with the aim of finding the effects of different levels of humic acid on seedling growth and macro and micronutrient contents of tomato and eggplant seedlings.

MATERIALS AND METHODS

This study was undertaken to determine the effects of humic acid on seedling growth and macro and micronutrient contents of tomato (cv. Sandoz-182) and eggplant (cv. Pala Yalova- 49) under greenhouse conditions at the Department of Horticulture at Agriculture Faculty, Atatürk University, in Erzurum, Turkey.

Different levels of humic acid (50, 100, 150, and 200 ml l^{-1}) were applied to the growth media. This humic acid (HA) used contained 5% N, P_2O_5 and K_2O, 1% Ca, Fe, Zn and Mg; 200 mg kg^{-1} Mn, 90 mg kg^{-1} B, 14 mg kg^{-1} Cu,5 mg kg^{-1} Co and 8 mg kg^{-1} Mo.

Peat in 1 liter pots was used as growth medium. Experimental layout was a completely randomized design with three replicates and each replication had 30 plants. Data were subjected to analysis of variance (ANOVA) and the means were compared according to Duncan Test (Düzgüneş et al., 1987) except for application of 200 ml l^{-1} HA in tomato seedlings because of its inhibition effect (Table1).

Humic acid was applied four times to the peat after transplanting of seedlings with ten day intervals, starting from transplanting.

Number, width, and length of leaves; length, diameter, fresh weight, dry weight of stems and roots (Ertan and Sevgican, 1992) were determined. Macro and micronutrient (N, P, K, Ca, Mg, Na, Cu, Fe, Mn, Zn and Cu) plant nutrient contents of seedling were also determined in both species (Kacar, 1972).

RESULTS AND DISCUSSION

Seedling Growth

Application of humic acid (HA) affected positively the numbers, width, and length of leaves; length, width, fresh weight, and dry weight of stems; length, fresh weight and dry weight of roots in both species (Table 1 and 2).

Leaves: Numbers and lengths of leaves in tomato seedling were significantly higher at 50 ml l^{-1} HA or 100 ml l^{-1} HA levels compared to 150 ml l^{-1} HA and control, respectively. There was a significant reduction in length due to the 150 ml l^{-1} HA treatment compared to control. The differences in leaf width between treatments were not significant (Table 1).

Table 1

The effects of humic acid levels on tomato seedling growth

HA App. Levels	Leaf			Stem				Root		
	Num.	Width (cm)	Length (cm)	Length (cm)	Diameter (cm)	Fr.Wt. ($g\ s^{-1}$)	Dry Wt. ($g\ s^{-1}$)	Length (cm)	Fr.Wt. ($g\ s^{-1}$)	Dry Wt. ($g\ s^{-1}$)
50 ml l^{-1}	12.3 a	20.33 a	20.3 a	30.8 a	0.46 a	21.2 a	3.13 a	24.5 a	2.9 a	1.8 ab
100 ml l^{-1}	12.7 a	16.78 a	19.3 a	30.5 a	0.46 a	20.4 a	3.07 a	20.0 ab	13.8 a	2.2 a
150 ml l^{-1}	8.2 b	16.67 a	11.1 c	18.0 c	0.32 b	5.7 c	1.25 b	15.0 b	1.9 c	0.2 c
Control	8.2 b	17.92 a	15.5 b	24.8 b	0.42 a	14.3 b	2.21 a	19.2 ab	8.1 b	1.1 b
Duncan(0.05)	2.952	NS	4.550	3.283	0.065	5.576	1.368	5.635	4.356	0.78

Means with different letters were significantly different at $p < 0.05$ (Duncan Test)

NS: Not significant

In eggplant seedlings, numbers, widths, lengths of leaves were higher at 50 ml l^{-1} HA, 100 ml l^{-1} HA, and 150 ml l^{-1} HA levels compared to 200 ml l^{-1} HA, and the control, respectively. Leaf number, leaf width, and leaf length showed significant differences at 50, 100, and 150 ml l^{-1} HA compared to 200 ml l^{-1} HA and control treatments (Table 2).

Table 2

The effects of humic acid levels on eggplant seedling growth

HA App. Levels	Leaf			Stem				Root		
	Num.	Width (cm)	Length (cm)	Length (cm)	Diameter (cm)	Fr.Wt. (g s^{-1})	Dry Wt. (g s^{-1})	Length (cm)	Fr.Wt. (g s^{-1})	Dry Wt. (g s^{-1})
50 ml l^{-1}	6.33 a	8.71 a	15.5 a	12.0 a	0.51 a	9.6 b	1.3 a	16.5 a	6.2 ab	0.49 a
100 ml l^{-1}	7.17 a	9.08 a	14.3 a	13.3 a	0.56 a	13.3 a	1.5 a	15.5 a	10.7 a	0.61 a
150 ml l^{-1}	7.00 a	8.75 a	14.6 a	11.7 a	0.54 a	11.8 ab	1.4 a	13.8 b	5.0 ab	0.18 a
200 ml l^{-1}	4.50 b	5.21 b	8.6 b	6.5 b	0.35 b	3.0 c	0.3 b	9.0 c	1.8 b	0.04 a
Control	4.00 b	4.58 b	7.6 b	4.7 b	0.36 b	2.9 c	0.3 b	9.7 c	2.1 b	0.04 a
Duncan (0.05)	1.126	1.742	3.298	2.729	0.072	3.094	0.722	2.360	5.782	NS

Means with different letters were significantly different at $p < 0.05$ (Duncan Test)

Stem: In tomato seedlings, length and fresh weight of stems were higher at 50 ml l^{-1} HA and 100 ml l^{-1} HA treatments and they were significantly different from all other treatments. The parameters also showed significant differences between 150 ml l^{-1} HA and the control. The diameters and dry weights of stems were higher at 50 ml l^{-1} HA, 100 ml l^{-1} HA and the control, and they were significantly different from the 150 ml l^{-1} HA treatment (Table 1).

Length, diameter and dry weight of stems in eggplant seedlings were higher at 50 ml l^{-1} HA 100 ml l^{-1} HA, and 150 ml l^{-1} HA, and they showed significant differences from 200 ml l^{-1} HA, and control. Fresh weight of the seedlings was highest at 50 ml l^{-1} HA. Fresh weights of stems of the 100 and 150 ml l^{-1} HA treated plants were also higher than controls but significant different from the 50 ml l^{-1} HA treatment. The fresh weight of controls and the 200 ml l^{-1} HA treated seedlings were not significantly different from each other but differed from the other treatments (Table 2).

Root: Lengths of roots of tomato seedlings were highest at 50 ml l^{-1} HA, 100 ml l^{-1} HA and control treatments, and they were significantly different from the 150 ml l^{-1} HA treatment. Fresh weights of roots were higher in 50 ml l^{-1} HA and 100 ml l^{-1} HA treatments compared to 150 ml l^{-1} HA and the control treatments. Dry weights of the roots were significantly higher at 100 ml l^{-1} HA compared to all other treatments (Table 1).

In eggplant seedlings, the root length was higher at 50 ml l^{-1} HA and 100 ml l^{-1} HA treatments and showed significant differences from 150 ml l^{-1} HA, 200 ml l^{-1} HA and the control treatments. Fresh weights of roots were highest at 100 ml l^{-1} HA, and different from all other treatments. There were significant differences between the treatments in the dry weight of roots (Table 2).

Nutrient Contents

N Content: Treatments and cultivars significantly affected N content in tomato and eggplant leaf tissues (Table 3 and 4). The highest N contents were obtained from 100 ml l^{-1} HA application in tomato and 150 and 200 ml l^{-1} HA applications in eggplant, respectively. All humic acid treatments in both species significantly increased N contents of leaves in comparison to the control.

P Content: Phosphorus content of tomato and eggplant were higher in the plants treated by the 100 ml l^{-1} and 200 ml l^{-1} HA applications than the other applications and control, respectively (Table 3 and 4). There were statistically significant differences among them.

K Content: The highest K content in both species occurred in plants treated with 100 and 150 ml l^{-1} HA application in tomato and 200 ml l^{-1} HA application in eggplant as compared to the controls, and there were significant differences among the other applications and control (Table 3 and 4).

Mg Content: Mg content of tomato and eggplant significantly increased in the plants treated by HA and highest Mg contents of tomato and eggplant were obtained from 100 ml l^{-1} HA and 200 ml l^{-1} HA application, respectively, as compared to the control (Table 3 and 4).

Ca Content: The Ca contents of tomato and eggplant were significantly influenced by HA applications and highest Ca contents were determined in 150 ml l^{-1} HA application in tomato and 200 ml l^{-1} HA in eggplant when they were compared to the control (Table 3 and 4).

Na Content: All HA application in tomato and 200 ml l^{-1} HA application in eggplant significantly increased the content of Na comparing to the control in tomato and other applications and control in eggplant (Table 3 and 4).

Fe Content: HA applications significantly affected the contents of Fe in tomato and eggplant when compared to the control. The highest values were obtained from 150 ml l^{-1} HA application in tomato and 200 ml l^{-1} HA application in eggplant (Table 3 and 4).

Mn Content: Mn content of tomato and eggplant significantly increased in plants treated by HA applications. The highest Mn contents of tomato and eggplant were obtained from 150 ml l^{-1} HA and 200 ml l^{-1} HA applications as compared to the controls, respectively (Table 3 and 4).

Zn Content: The highest Zn content of tomato and eggplant were determined in the plants treated by 150 ml l^{-1} HA applications, respectively (Table 3 and 4) and the applications significantly affected the contents of Zn in both plants when compared to the control.

Cu Content: The highest Cu content in tomato was determined from 150 ml l^{-1} HA application. However, no significant effect of HA applications on the Cu content was obtained in tomato. HA applications significantly affected the contents of Cu in eggplant when compared to the control. The highest value was obtained from 100 ml l^{-1} HA application in eggplant (Table 3 and 4).

Table 3

The effects of humic acid levels on macro and micronutrients in seedling of tomato

Treatments	N (%)	P (%)	K (%)	Mg (%)	Ca (%)	Na (%)	Fe mg kg^{-1}	Mn mg kg^{-1}	Zn mg kg^{-1}	Cu mg kg^{-1}
50 ml l^{-1}	3.52 b	0.60 b	2.52 b	0.57 ab	3.31 a	0.94 a	222.2 b	96.15 ab	207.1 c	16.67 NS
100 ml l^{-1}	5.34 a	0.83 a	3.52 a	0.59 a	3.51 a	1.08 a	287.6 b	106.24 a	222.5 bc	18.54
150 ml l^{-1}	4.08 b	0.60 b	3.45 a	0.51 c	3.52 a	0.94 a	305.7 ab	120.47 a	277.4 a	18.55
Control	1.14 c	0.43 b	2.31 b	0.56 b	2.63 b	0.36 b	132.7 c	76.45 b	189.8 c	14.81
Duncan(0.05)	1.380	0.213	0.912	0.0195	0.542	0.221	102.121	18.75	59.87	NS

NS: Not significant $p < 0.05$ (Duncan Test)

Table 4

The effects of humic acid levels on macro and micronutrients in seedling of eggplant

Treatments	N (%)	P (%)	K (%)	Mg (%)	Ca (%)	Na (%)	Fe mg kg^{-1}	Mn mg kg^{-1}	Zn mg kg^{-1}	Cu mg kg^{-1}
50 ml l^{-1}	5.40c	0.29c	2.27d	0,98b	3.65c	0.56d	153.5b	25.23bc	165.1bc	14.25ab
100 ml l^{-1}	6.89b	0.31bc	2.50bc	1.01b	4.81b	0.77bc	146.1b	34.53abc	203.3bc	15.21a
150 ml l^{-1}	7.64a	0.32b	2.58b	1.02b	5.57b	0.96b	195.0a	38.56ab	221.1ab	15.19a
200 ml l^{-1}	8.10a	0.37a	2.99a	1.15a	6.68a	1.49a	227.7a	50.81a	246.1ab	14.08ab
Control	2.49d	0.27d	2.08d	0.85c	2.85c	0.38d	135.9b	16.38c	117.96c	10.05c
Duncan(0.05)	0.587	0.018	0.384	0.110	1.115	0.216	35.672	12.268	28.631	1.596

Humic acid remarkably increased seedling growth but was dependent on the parameters investigated. The most promising results were obtained at applications of 50 ml l^{-1} HA or 100 ml l^{-1} HA in tomato seedlings and 50 ml l^{-1} HA and 150 ml l^{-1} HA in eggplant seedlings. Similar results have been reported by Vaugham and Malcolm (1986), Sanchez-Adreu et al., (1994) and Deffune and Schofield (1997). High concentrations of humic acid had negative effects on the seedling growth in this study. Piccole et al., (1992) and Sanchez-Adreu et al., (1994) reported similar result for tomato seedlings.

Depending on the levels of HA applications N, K, Na, Fe, Mn, Zn, Ca and Cu contents of plants significantly increased. Increasing N contents of plants affected P, Na, Ca and Fe contents of plants and also significantly affected K, Mn, Cu contents and number of leaves of plants. Na and Ca contents of plants affected P contents of plants and there were relations between K, Fe and the number of the plants.

Mg contents of plants positively affected the number of leaves, leaf width, stem diameter, stem fresh and dry weight and root fresh weight but Zn content negatively affected.

Similar results were reported by some authors such as Csizinszky (1990) on bell pepper, Csizinszky et al. (1990) on pepper and tomato, Verkleij (1992) on horticultural crops, Sanchez-Adreu et al. (1994) and Böhme and Thia Lua (1997) on tomato.

In conclusion, result of this study indicate that humic acid applied to the plant growth medium at low concentrations (50, 100 and 150 ml l^{-1} HA) increased seedling quality, plant growth and nutrient contents both species. Therefore, it can be recommended to vegetable growers.

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Streszczenie

Wpływ różnych stężeń kwasu huminowego na wzrost siewek pomidora i oberżyny oraz ich skład chemiczny

W niniejszej pracy podjęto próbę określenia wpływu kwasu huminowego (HA) na wzrost siewek oraz zawartość makro- i mikroelementów w siewkach pomidora (*Lycopersicon esculentum* L.) i oberżyny (*Solanum melongena* L. var. *esculentum*) w warunkach szklarniowych. Stosowano 50, 100, 150 i 200 ml l^{-1} HA do podłoża (torf) co 10 dni od czasu przesadzenia siewek. Najlepsze wyniki w zakresie wzrostu liści, pędów i korzeni otrzymano po użyciu stężeń 50 i 100 ml l^{-1} HA w przypadku pomidora oraz 50, 100 i 150 ml l^{-1} HA w przypadku oberżyny. Najwyższą zawartość makro- i mikroelementów stwierdzono w roślinach pomidora po zastosowaniu roztworu o stężeniu 100 ml l^{-1}, a w roślinach oberżyny – 200 ml l^{-1} HA.