INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 7, No. 1, p. 132-140, 2015

RESEARCH PAPER OPEN ACCESS

Effect of humic, fulvic acid and calcium foliar application on growth and yield of tomato plants

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Key words: Tomato, foliar application, humic acid, fulvic acid, calcium, blossom end rot.

http://dx.doi.org/10.12692/ijb/7.1.132-140 Article published on July 14, 2015

Abstract

This study was laid out to determine the effect of humic, fulvic acid and calcium foliar application on growth, yield and fruits quality of tomato plants. A field experimental in completely randomized block design with three replications was conducted at the Agricultural Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt. The tomato transplants, 'H9663' cultivar, were grown on clay soil during the 2013 and 2014 seasons. The individual and combination applications of humic acid (0.4 %), fulvic acid (4%) and chelated calcium (0.25 %) solutions were applied as foliar sprays on tomato plants at four times (after two, four, six and eight weeks from transplanting). Growth and nutrients content (N, P, K and Ca) of tomato plants as well as yield and fruits quality were investigated in treated and untreated plants. Results indicated that all foliar applications of humic, fulvic acid and calcium , either individual or in combinations, increased vegetative growth, yield and fruit quality. On the other hand, these treatments decreased the incidence of blossom end rot in tomato fruits. Foliar application of humic acid plus fulvic acid plus calcium gave the maximum values in the investigated properties. In conclusion, application of humic, fulvic acid and calcium as foliar application improved the plant growth, yield and fruits quality of tomato.

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Introduction

Tomato (*Solanum lycopersicum*) is one of the most important and popular fruit vegetable crops grown in Egypt and many countries all over the world. The total cultivated area in Egypt was 515225 feddans, produced about 8571050 tons on annual basis with an average of productivity 16.636 tons/feddan in season 2012 (Ministry of Agriculture and Land Reclamation, 2013). It has many nutrition values such as high content of potassium, vitamins C and E, flavonoids, chlorophyll, β-carotene, and lycopene (Jones, 2008). Increasing the production of tomato with high quality is considered an important aim and this aim could be achieved through using the foliar application of humic, fulvic acid and calcium.

Humic substances such as humic acid, 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 (Cacco & Dell Agnolla, 1984, Russo & Berlyn, 1990 and Fahramand *et al.,* 2014). Foliar spraying of humic acid promoted growth in many plants such as tomato, cotton and grape (Brownell *et al.,* 1987). Karakurt *et al.* (2009) reported that humic acid application affected pepper growth and fruit characteristics and had positive influence on quantitative and qualitative of pepper plant. Ameri and Tehranifar (2012) reported that spraying strawberry plants with humic acid enhanced X nutrient uptake (N, P and K) and physiological characteristics of fruits. Also, HosseiniFarahi *et al.* (2013) suggested that foliar application of humic acid led to improvement of quantitative and qualitative characteristics of strawberry (chlorophyll content, fruit number, total yield of plant, TSS and fruit firmness).Yildirim (2007) mentioned that foliar application of humic acid on tomato plants increased product quantity and quality.

Fulvic acid accelerates cellular division thus stimulates vegetable growth and development as well as increase of cellular energy and regulation of plant metabolism to prevent nitrate compounds from accumulation in plants and increases x resistance to insects and diseases by encouraging tolerance to extreme temperatures such as heat and coldness and many other physical factors (Jackson, 1993). Fulvic acid chelates and binds scores of minerals into a bio-available form used by cells. These trace minerals serve as catalysts to vitamins within the cell. Additionally, fulvic acid is one of the most efficient transporters of vitamins into the cell (Williams, 1977). Fulvic acid stimulates and balances cells, creating optimum growth and replication conditions (Poapst and Schnitzer, 1971). It enhances the permeability of cell membranes (Christman and Gjessing, 1983). There were research revealed that the treated plants with fulvic acid had significant beneficial effects on roots and shoots (McCarly, 1985) of tomato and (Khang, 2011) x rice and radish. Fulvic acid is particularly preferred in that it allows surrounding stress to decrease, helps absorb other minerals and positively contributes to yield and quality (Bethke *et al.,* 1987).

Calcium is one of the nutrients which are multi-functional in plant physiology and vital for vegetative growth and development (Assmann, 1995 and Marschner, 1995).They are important intracellular messengers, mediating responses to hormones, biotic and abiotic stress signals and a variety of developmental processes (Reddy and Reddy, 2004). In most fruits, firmness retention is an important quality parameter in fresh-cut fruits and vegetable products. The preharvest nutritional status of fruit, especially with respect to calcium, is an important factor affecting potential storage life (Fallahi, *et al.,* 1997). Foliar applications of calcium chloride improved fruits quality, delayed ripening and retard fungal growth on strawberries (Wojcik and Lewandowski, 2003). Peyvast *et al.* (2009) reported that foliar application of calcium could increase tomato yield and yield components with high quality. Foliar application of humic acid and calcium alone or in combination improved growth parameters, yield and fruit quality of tomato; On the other hand, it decreased the incidence of blossom end rot. The combination treatment was more effective than

individual application (Kazemi, 2013). Foliar application of fulvic acid and calcium with trace elements enhanced X yield, quality and nutritional status of tomato plants (Yildirim and Unay, 2011).
The aim of the present was to study the effects of foliar spraying of humic, fulvic acid and calcium alone or in combination on the growth, yield, fruit quality characteristics and blossom end rot incidence of tomato fruits.

Materials and methods

The field trial was conducted during the two growing summer seasons of 2013 and 2014 at the Agricultural Experimental Station, Faculty of Agriculture, Cairo University, El-Giza Governorate, Egypt to investigate the influence of humic, fulvic acid and calcium foliar application on growth, yield and fruits quality of tomato plants. Tomato transplants ('H9663' F1 cultivar) were planted in the field on 13 and 17 of February in the first and second seasons, respectively. The experimental trial was conducted in clay soil using drip irrigation system. The experimental soil was analyzed according to FAO (1980) and is presented in Table (1).

The soil of the experiment was ploughed after addition of 5 ton commercial compost / feddan and divided into rows; each plot contained three rows of 1 m width and 10 m length. The space between plants was 50 cm, one line on each row. The drip irrigation system consisted of polyethylene hoses GR (4 l h^{-1}) of 16 mm in diameter, allocating one hose for each row. Irrigation frequency was every 2 days to maintain soil moisture above 50% according to Qassim and Ashcroft (2002), which is the optimum moisture level of tomato plants.

All plots received N, P and K fertilizers at the rates of 125 - 45 - 48 kg $feddan^{-1}$ as ammonium sulfate (20.5%N), phosphoric acid (58% P_2O_5) and potassium sulfate (48% K_2O). The fertilizer solutions were injected directly into the irrigation water using a venture injector at two doses weekly. Other recommended agricultural practices were followed as commonly used in the commercial production of tomato.

The individual and combination applications of humic acid (0.4 %), fulvic acid (4 %) and chelated calcium on amino acids (0.25 %) solutions were applied as foliar sprays on tomato plants at four times, namely, 2, 4, 6 and 8 weeks after transplanting. The control plants were not treated.

The treatments of this experiment were arranged in a completely randomized block design with three replicates.

After 60 days from transplanting, three plants from each replicate were randomly chosen to measure plant length, stem diameter, number of leaves and clusters for plant. Total nitrogen, phosphorous, potassium and calcium were determined in the dry matter of fourth leaf according to Cottenie *et al.* (1982). Total nitrogen was determined by Kjeldahl method according to the procedure described by FAO (1980). Phosphorus content was determined using spectrophotometer according to Watanabe and Olsen (1965). Potassium and calcium content were determined spectrometrically using Phillips Unicum Atomic Absorption Spectrometer as described by Chapman and Pratt (1961). Fresh and dry shoot weight of plants was measured at harvesting.

Total yield for each plot were recorded accumulatively after each harvesting and were collected for feddan. The percentage of blossom end rot incidence (BER) was estimated by counting the total number of fruits and fruits showing symptoms of blossom end rot in each treatment. The blossom end rot incidence is expressed as a percentage of total fruits.

Five ripe fruits were selected randomly to measure some fruit characteristics. Fruit firmness was measured by penetrometer (Lfra Texture Analyzer) using a penetrating needle of 1 mm of diameter, 3 mm in distance and speed of 2 mm/second and the peak of resistance was recorded as g mm^{-2}. Total soluble solids (TSS) were measured by using a digital Refractometer. Titratable acidity was determined in

fresh juice of fruit samples by titration against sodium hydroxide (Na OH) using phenolphthalein as well as, vitamin C in fruits according to the described method in AOAC (2005).

Data of the two seasons were arranged and statistically analyzed by the analysis of variance using one way ANOVA with SAS package. Comparison of treatment means was done using Tukey test at significance level 0.05.

Results and discussion

The effects of different treatments on tomato plants growth by are presented in Tables 2 and 3. The results in these tables reveal that foliar application of humic, fulvic acid and calcium as individual or in combinations significantly increased fresh and dry shoot weight compared with control treatment. The highest values of fresh and dry shoot weight were recorded for plants sprayed with a mixture of humic, fulvic acid and calcium, whereas the untreated plants produced the lowest values. Similar results were obtained with the other vegetative growth parameters (plant length, stem diameter and number of leaves) and number of cluster. This increment in plants growth may be due to the positive effect of humic substances (humic and fulvic acid) that increased cell membrane permeability, respiration, photosynthesis, oxygen and phosphorus uptake and root cells growth. X Fulvic acid is one of the most efficient transporters of vitamins into the cell (Poapst and Schnitzer 1971; Williams 1977; Christman and Gjessing 1983; Cacco & Dell Agnolla, 1984; Russo & Berlyn, 1990; Jackson, 1993 and Fahramand *et al.,* 2014). The good plants growth might also be due to a benefit effect of calcium which has multi-functional role in plant physiology and vital for vegetative growth and development (Assmann, 1995 and Marschner, 1995). These results are in the same line with those obtained by McCarly (1985), Brownell *et al.* (1987), Karakurt *et al.* (2009) and Khang (2011).

Table 1. The analyses of the experimental soil.

Clay %	Silt %	Sand %	Texture	pH	EC dS/m	Cations meq/l				Anions meq/l			
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Co_3^{-}	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
90.76	5.52	3.72	Clay	7.77	0.85	1.32	0.43	3.33	0.52	0.24	1.27	2.74	3.53

Table 2. Effect of foliar application with HA, FA and Ca on fresh & dry weight of shoot and stem diameter of tomato plants during 2013 and 2014 seasons.

Treatments	Fresh weight kg/plant				Dry weight g/plant				Stem diameter mm			
	1st season		2nd season		1st season		2nd season		1st season		2nd Season	
Control	2.31	f	2.43	e	330	f	344	f	11.33	f	11.80	e
Humic acid	2.80	c	2.89	c	399	cd	410	c	15.93	c	16.33	bc
Fulvic acid	2.62	de	2.76	cd	377	de	390	de	14.00	de	14.57	cd
Calcium	2.50	e	2.61	de	359	e	371	e	13.33	e	13.88	d
HA + Ca	2.86	c	3.06	b	418	cd	438	b	16.33	c	16.83	b
FA + Ca	2.72	cd	2.83	c	389	d	402	cd	15.33	cd	16.00	bc
HA + F	3.19	b	3.57	a	457	b	513	a	18.33	b	19.17	a
HA + F + Ca	3.55	a	3.72	a	505	a	529	a	21.00	a	21.00	a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

HA = Humic acid

FA = Fulvic acid

Ca = Calcium.

The effect of different treatments on nutrition status of tomato plants is illustrated in Table 4. Such data indicated that all foliar application treatments significantly increased all nutrients (N, P, K and Ca)

in the leaves. The highest concentration of N was found in humic plus fulvic acid plus calcium treatment compared to other treatments. On the other hand, the highest concentration of P was found in humic plus fulvic acid plus calcium treatment. However, there were no significant differences between this treatment and the treatment of humic + fulvic acid. Besides the maximum concentrations of K and Ca were preceded by humic plus fulvic acid plus calcium treatment with no significant differences between this treatment and humic acid plus calcium treatment.

Table 3. Effect of foliar application with HA, FA and Ca on plant length, leaves and clusters number of tomato plants during 2013 and 2014 seasons.

Treatments	Plant length cm				Leaves number				clusters number			
	1st season		2nd season		1st season		2nd season		1st season		2nd Season	
Control	52.00	g	55.16	f	32.67	e	34.67	e	12.67	f	12.83	e
Humic acid	64.67	d	71.29	d	43.33	c	44.67	c	16.33	cd	18.00	c
Fulvic acid	60.67	ef	66.71	de	40.67	cd	42.67	cd	15.00	de	15.67	d
Calcium	57.33	f	62.09	ef	37.00	d	38.67	de	13.67	ef	14.67	de
HA + Ca	70.67	c	77.21	c	47.67	b	50.67	b	18.33	cd	19.00	c
FA + Ca	63.67	de	70.21	d	43.33	c	45.00	c	16.67	cd	17.67	c
HA + F	80.00	b	86.64	b	51.33	b	54.33	b	20.67	b	21.67	b
HA + F + Ca	88.67	a	93.53	a	57.00	a	60.33	a	24.33	a	24.77	a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

HA = Humic acid

FA = Fulvic acid

Ca = Calcium.

Table 4. Effect of foliar application with HA, FA and Ca on nutrient content (N,P, K and Ca) of tomato plants during 2013 and 2014 seasons.

Treatments	N				P				K				Ca			
	%															
	1st season		2nd season		1st season		2nd season		1st season		2nd season		1st season		2nd season	
Control	2.40	f	2.44	g	0.338	f	0.464	e	2.33	e	2.37	d	0.95	e	1.10	f
Humic acid	3.20	cd	3.46	cd	0.740	bc	0.782	c	3.28	bc	3.44	b	1.58	d	1.66	e
Fulvic acid	2.90	cd	3.11	e	0.667	d	0.755	c	2.67	d	2.87	c	1.48	d	1.56	e
Calcium	2.63	ef	2.84	f	0.541	e	0.625	d	3.13	c	3.38	b	2.19	b	2.29	c
HA + Ca	3.43	bc	3.63	bc	0.770	b	0.835	b	3.46	ab	3.76	a	2.38	ab	2.54	ab
FA + Ca	3.13	cd	3.35	de	0.697	cd	0.775	c	3.27	bc	3.48	b	2.26	b	2.38	bc
HA + F	3.67	bc	3.88	b	0.840	a	0.903	a	3.32	bc	3.51	b	1.86	c	1.96	d
HA + F + Ca	4.09	a	4.23	a	0.857	a	0.917	a	3.65	a	3.87	a	2.55	a	2.62	a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

HA = Humic acid

FA = Fulvic acid

Ca = Calcium.

These results are harmony with those obtained by Ameri and Tehranifar (2012) they reported that spraying of humic acid on strawberry plants enhanced of nutrient uptake (N, P and K). Also these results are agreement with those obtained by Bethke *et al.* (1987) who reported that Fulvic acid helps the plants to absorb other minerals; and Yildirim & Unay (2011) who indicated that foliar application of fulvic acid and

calcium with trace elements enhance the nutritional status of tomato plants.

The effects of different treatments on total yield and blossom end rot incidence in tomato fruits are showed in Table 5. The obtained results revealed that all spraying plants with humic, fulvic acid and calcium significantly increased yield of tomato plants in comparison with untreated plants. Using combination of the three compounds, i.e, humic, fulvic acid and calcium, gave the highest value of total yield, while a combination of the two solutions (humic plus fulvic acid, humic acid plus Ca and fulvic acid plus Ca) came in the second position in this respect. On the other hand, the individual treatments (humic acid, fulvic acid and Ca) came in the third position; finally untreated plants gave the lowest yield. These results are supported by Yildirim (2007) and HosseiniFarahi *et al.* (2013) who suggested that foliar application of humic acid led to improvement of quantitative and qualitative characteristics of tomato and strawberry respectively. On another hand, Peyvast *et al.* (2009) reported that foliar application of calcium could increase yield of tomato. Also Yildirim and Unay (2011) indicated that foliar application of fulvic acid and calcium with trace elements enhanced the yield of tomato. As well as Osman *et al.* (2013) mentioned that foliar application of humic and fulvic acid together increased rice yield and its components.

Table 5. Effect of foliar application with HA, FA and Ca on total yield and blossom end rot in fruits of tomato during 2013 and 2014 seasons.

Treatments	Total yield (Ton/feddan)				Blossom end rot (%)			
	1st season		2nd season		1st season		2nd season	
Control	27.11	h	27.83	f	32.00	a	33.67	a
Humic acid	31.32	e	33.33	cd	14.00	cb	15.00	bc
Fulvic acid	30.49	f	31.83	d	16.33	b	17.00	b
Calcium	28.61	g	29.67	e	6.67	d	7.00	d
HA + Ca	33.53	c	35.17	b	5.67	d	5.67	d
FA + Ca	32.12	d	33.67	bc	6.00	d	6.50	d
HA + F	34.71	b	36.83	a	13.00	c	13.33	c
HA + F + Ca	35.48	a	37.50	a	4.67	d	5.00	d

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

HA = Humic acid

FA = Fulvic acid

Ca = Calcium.

Concerning the blossom end rot incidence in tomato fruits, the results indicated that foliar application of humic, fulvic acid and calcium as individual or combination decreased the incidence of blossom end rot. All calcium treatments alone or combination gave the lowest blossom end rot incidence in the fruits. These results agreed with that found by Kazemi (2013) who showed that foliar application of humic acid and Calcium alone or in combination decreased the incidence of blossom end rot in tomato fruits; with notice the combination treatment was more effective than individual application. The blossom end rot of tomato fruit is a physiological disorder resulting from calcium deficiency (Del-Amor and Marcelis, 2003). It reduces fruit quality and market value (Taylor *et al.,* 2004). The blossom end rot incidence can be aggravated by the deficiency of other nutrients such as NH_4-N, K, and Mg (Navarro *et al.,* 2005).

Concerning fruit characters of tomato the results in Table 6 indicated that fruit firmness, total soluble solid and vitamin C content of tomato fruits were

significantly increased with all foliar application treatments, as individual or in combinations, whereas titratable acidity in tomato fruits was significantly decreased in both seasons. The favorable fruit characters was obtained from plants x received the combination of humic, fulvic acid and calcium, while unfavorable effects on fruit quality were observed with untreated plants x. These results may be due to a positive effect of humic substances (humic and fulvic acid) that increased cell membrane permeability, respiration and photosynthesis in plant (Cacco & Dell Agnolla, 1984, Russo & Berlyn, 1990 and Fahramand *et al.,* 2014), and also may be due to a benefit effect of calcium which has physiological and vital roles for development processes and fruit quality (Assmann, 1995; Marschner, 1995, Fallahi, *et al.,* 1997; Wojcik and Lewandowski, 2003 and Reddy & Reddy, 2004). These results are supported by the findings of Yildirim and Unay (2011) who found that foliar application of fulvic acid and calcium with trace elements enhanced x yield and fruit quality of tomato. Also these results are supported by Kazemi (2013) who reported that foliar application of humic acid and Ca alone or in combination improved yield and fruit quality of tomato with notice that the combination treatment was more effective than individual application.

Table 6. Effect of foliar application with HA, FA and Ca on fruit characters of tomato during 2013 and 2014 seasons.

Treatments	Fruit firmness g/mm²				TSS %				Titratable acidity %				V.C mg/100g			
	1st season		2nd season		1st season		2nd season		1st season		2nd season		1st season		2nd season	
Control	44.00	f	27.83	f	4.70	d	4.95	d	2.86	a	3.02	a	14.96	e	15.48	e
Humic acid	50.33	d	33.33	cd	5.60	c	5.93	c	2.60	bc	2.67	b	15.94	bc	16.51	bc
Fulvic acid	47.33	e	31.83	d	5.47	c	5.77	c	2.64	bc	2.71	b	15.69	cd	16.23	cd
Calcium	53.33	c	29.67	e	5.63	c	5.94	c	2.60	bc	2.64	b	15.56	d	16.09	d
HA + Ca	56.00	b	35.17	b	6.53	b	6.94	ab	2.54	bc	2.68	b	16.20	ab	16.76	ab
FA + Ca	54.67	bc	33.67	bc	5.97	bc	6.29	bc	2.60	bc	2.74	b	15.97	bc	16.56	bc
HA + F	50.67	d	36.83	a	6.07	bc	6.33	bc	2.55	bc	2.69	b	16.43	a	16.99	a
HA + F + Ca	58.67	a	37.50	a	7.40	a	7.67	a	2.52	c	2.35	c	16.52	a	17.09	a

Means followed in same column by similar letters are not statistically different at 0.05 level according to Tukey test.

HA = Humic acid

FA = Fulvic acid

Ca = Calcium.

Conclusion

It can be concluded from these results that foliar application with humic, fulvic acid and calcium as individual or in a combination improved growth parameters, yield and fruit quality of tomato; and decreased the incidence of blossom end rot. The combination treatment with the three solutions was the most effective.

Acknowledgement

This work has been supported by Central Lab of Organic Agriculture, Agriculture Research Center – Vegetable and Soils Departments, Faculty of Agriculture, Cairo University - Horticulture Departments, Faculty of Agriculture, Suez Canal University.ما اهمية هذه الجملة

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يفضل ان يوحد اسماء المجلات بكتابتها مختصرة دائما

الملخص العربى

تاثير الرش الورقى بحمض الهيوميك والفولفيك والكالسيوم على نمو وانتاج نباتات الطماطم

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لدراسة تاثير الرش الورقى بحمض الهيوميك والفولفيك والكالسيوم على نمو وانتاج وجودة ثمار نباتات الطماطم . أجريت تجربة حقلية بتصميم قطاعات كاملة العشوائية فى ثلاث مكررات فى المزرعة البحثية التابعة لكلية الزراعة – جامعة القاهرة – جمهورية مصر العربية . تم زراعة شتلات الطماطم صنف هاينز9663 هجين فى تربة طينية خلال موسمى 2013 و2014 . تم استخدام محاليل منفردة ومخلوطة من حمض الهيوميك (0.4%) والفولفيك (4%) والكالسيوم المخلبى (2.5%) كرش ورقى على نباتات الطماطم بعد 2 و 4 و 6 و 8 اسابيع من الشتل . تم دراسة النمو والمحتوى الغذائى لنباتات الطماطم كما تم دراسة المحصول وجودة الثمار فى النباتات المعاملة والغير معاملة.

واشارت النتائج الى ان كل معاملات الرش الورقى لحمض الهيوميك والفولفيك والكالسيوم سواء منفردة او مخلوطة زادت من النمو الخضرى والمحصول وجودة الثمار . من جهة اخرى هذه المعاملات قللت من الاصابة بعفن الطرف الزهرى فى ثمار الطماطم . الرش الورقى بمخلوط حمض الهيوميك والفولفيك والكالسيوم اعطى اعلى قيم للصفات التى تم دراستها . خلاصة الدراسة الى ان الرش الورقى بحمض الهيوميك والفولفيك والكالسيوم يحسن من نمو النباتات والمحصول وجودة ثمار الطماطم