Zagazig J. Agric. Res., Vol. 39 No. (5) 2012 817-836

Zagazig Journal of Agricultural Research
www.zu.edu.eg/agr/journals

RESPONSE OF SOME NEW TOMATO HYBRIDS TO FOLIAR SPRAY WITH SOME ORGANIC MACRO AND MICRO NUTRIENTS

Sally A. Midan*

Horticulture Dept., Faculty of Agriculture, Minufiya University

ABSTRACT

A field experiment was conducted during the winter seasons of 2010/2011 and 2011/2012 to study the effect of some organic macro and micro nutrients such as NPK-humate, chelated micro-elements, organic K-citrate and organic Ca citrate on growth, chemical constituents and productivity of three tomato hybrids, i.e., GS-12, TH 99806 and NSX 9535. All applied treatments showed superior effects on plant height, number of leaves, number of branches, as well as fresh and dry weights of roots stems and leaves. Moreover, all used organic nutrients increased chlorophyll a and b, carotenoids contents and N, P, K% in leaves and their utilization quotient. The most effective treatment for increasing early and total yields and improved yield quality (total soluble solids (T.S.S) and vitamin C in fruits) was foliar application of tomato plants by NPK humate. While spraying plants with organic chelated micro-nutrients and K citrate as well as Ca citrate decreased NO_3 accumulation in fruits.

Keywords: NPK-humate, chelated micro-elements, organic K-citrate, organic Ca citrate.

INTRODUCTION

Tomato is one of the most important vegetable crops grown in Egypt for fresh consumption and processing. Tomato fruits contain some important nutritional compounds such as minerals and vitamins.

In field experiments where mineral fertilizers had only been used, some problems could arise, especially increased soil erosion, soil composition, environmental pollution and public health risk (Top *et al.,* 2002).

Thus, using some organic forms of macro and micro-nutrients in tomato fertilization approved to be effective to avoid soil and environmental pollution.

The management of tomato crop is somewhat more different than leafy crops because the nutrient demands of the plant change during different stages of plant growth. At fruit setting stage, it requires more Ca, Mg and K (Nelson, 2008). At this time the nutrients can be applied as foliar spraying which is recognized as a very efficient method of plant nutrition (Chauduni and De, 1975; Giskin *et al.,* 1984; Komosa, 1990).

In this context, humic acid is particularly used for increasing the nutrients availability, which may positively reflected on plant growth (Abd El-Al *et al.,* 2005). In addition, humic substances can chelate most metals present in the soil, thereby increasing their availability to plants (Stevenson, 1994). Humic acid also had effect on root growth and root-hairs (Pinton *et al.,* 1999).

Besides, using K in organic forms as foliar spraying on garlic significantly increased plant growth (El-Morsy *et al.,* 2004).

Therefore, the objectives of this research were to investigate effects of foliar application of some organic macro and micro-nutrients on tomato growth, chemical constituents and yield.

* **Corresponding author:** **Tel.:** +201005256021
E-mail address: sally.midan@yahoo.com

MATERIALS AND METHODS

This work was carried out during two winter seasons of 2010/2011 and 2011/2012 at the Experimental Station Farm of the Faculty of Agriculture, Minufiya University, to study the effect of some organic macro and micro nutrients; i.e., NPK humate, chelated micro-elements, organic K-citrate and organic Ca-citrate on growth, chemical constituents and productivity of three new tomato hybrids; i.e., GS-12, TH 99806 and NSX 9535.

Seeds of tomato hybrids were sown in seed bed on 11^{th} of September and transplanted in the open field on 4^{th} of October in 2010 and 2011 seasons.

Transplants were set on one side of the rows, 80 cm width and 4 m. long, with 40 cm between transplants. Each experimental unit consisted of 4 rows as the plot area was 12.8 m^2. Plots were separated by 1 m from its counterpart neighbour plot to reduce treatment overlapping as possible.

All of the used organic macro and micro-nutrients in this study has been produced by the Ministry of Agriculture, Egypt.

NPK-humates: contain total organic acids, amino acids, humic acid, acid and organic NPK (8-8-8%). It was sprayed at the concentration of 5 cm^3/l.

Chelated micro-elements: contain Fe (3%), Cu (0.5%), Mg (1%), Ca_2 (2%), Mn (1.5%), B (0.5), N (1%), Zn (1.5%), Mo (1%), glucose (2%) and organic chelators: citrate and EDTA. It was sprayed at the concentration of 2 cm^3/l.

K-citrate: contain 46.6% K_2O (organic-K). It was sprayed at the concentration of 3.5 cm^3/l.

Ca-citrate: contain 25% Ca (organic-Ca) and 2% B. It was sprayed at the concentration of 4 cm^3/l.

All treatments solutions were sprayed four times, beginning at 20 days after transplanting every 20 days interval.

Split-plot design with four replicates was applied where tomato hybrids were designated as main plots and organic macro and micro-nutrients were employed as sub-plots. Four rows (4 m. long and 80 cm wide each) were devoted for each experimental unit, two of which were to study the vegetative growth and chemical composition, while the other two rows were left for yield investigation. The normal practices for growing tomato were carried out through the two growing seasons.

Four plants were randomly dug out from each experimental unit after 80 days from transplanting and subjected to the following measurements.

Growth Characteristics

Plant height (cm), number of branches and leaves / plant, as well as leaves, stems and roots fresh and dry weights (g), root length (cm) and leaf area/plant (cm^2) were measured according to Roods and Blood Worth (1964).

All parts of the vegetative sample (roots, leaves, stems) were separated and oven dried at 70°C for 72 hr to determine dry weight.

Biochemical Constituents of Leaves

a) Photosynthetic pigments: Chl. a , b and carotenoids contents were determined in fresh leaves following the method described by Witham *et al.* (1971).

b) Mineral elements: N, P and K were determined in dry leaves following the method described by A.O.A.C. (1990). Snell and Snell (1953) and Chapman and Pratt (1961), respectively.

c) N, P and K utilization quotient : It was estimated using the equation of Loneragan and Asher (1967).

Element utilization quotient = 1/ element concent × plant organ d.wt.

d) Total sugars in leaves: It was determined according to the method of Dubois *et al.* (1956).

e) Total free amino acids: It was determined in leaves according to the method of Rosen (1957).

Biochemical Constituents in Fruits

Fruit samples were undertaken from the third picking and the following constituents were determined:

a) Total soluble solids (T.S.S): It was recorded using a hand Abb Refractameter according to A.O.A.C (1990).

b) Vitamin C content (mg/100 ml of tomato juice): It was determind using the dye 2, 6-dichlorophenol indophenols method as described in A.O.A.C. (1990).

c) Nitrate (NO_3^-) accumulation: It was determined in the fresh fruits using the method of Woolly *et al.* (1960).

Yield and its Components

a) The early yield was expressed as the sum of fruit weight of the first three pickings.

b) Total yield was calculated from the first picking up to the last harvesting.

c) Number of fruits / plant.

d) Average fruit weight (g).

Statistical Analysis

All obtained data were subjected to statistical analysis using Costat-C programe (1985) and the LSD at 5% level (Snedecor and Cochran, 1972).

RESULTS AND DISCUSSION

Growth Characteristics

Plant height and number of branches and leaves

As it could be seen from data in Table 1, NPK-humate exerted superior records in all studied growth parameters. It was, generally, followed by potassium citrate, then came Ca-citrate and chelated micro-nutrients as check plants occupied the latest rank.

The superiority of NPK-humate was also noticed by Inaki *et al.* (2011) on pepper and Haghighi *et al.* (2010) who noticed that humic-N increased plant growth and stimulated plant biological activities. Further confirmation was done by Hebbar *et al.* (2004) who demonstrated that NPK enhanced tomato plant height, number of branches and some other growth parameters.

Such interpretation could be done as increasing NPK contents of plants that followed NPK humate application significantly affected Mn, Cu contents and consequently number of leaves. Similar conclusion was suggested on tomato by Bohme and Thi-Lau (1997) who stated that NPK humates could increase macro and micro nutrients content in plant.

As for the tested hybrids, TH 99809 showed superior records in plant height, number of branches and number of leaves (Table 1). It was followed by GS-12 hybrid as NSX 9535 came at the latest position.

Results could interpreted as hereditical factors controlled these growth parameters. The differences among cultivars in plant height and number of branches were reported by El-Sayed *et al.* (2010) working on sweet pepper.

As for the interaction between the two studied factors, TH 99809 hybrid is of pioneer position when it received NPK-humate (Table 1). Results appeared logic as the studied factors; i.e., TH 99809 hybrid and NPK-humate showed superior individual effects on the above mentioned growth parameters.

Leaves, stems, roots fresh and dry weights as well as root length

Economic yield is a part of the total biological yield of the crop and hence the dry matter production is an important determinant of the economic yield.

NPK-humate was insistently observed to favour fresh and dry weights of stems, leaves and roots (Tables 2 and 3). Similar trend was also noticed in root length. K-citrate came in the second rank as Ca-citrate, chelated micro-nutrients and control came descendingly at the third, fourth and fifth rank, respectively.

Significantly higher dry weight per plant was also reported by Hebbar *et al.* (2004) due to NPK application on tomato.

The superiority of NPK- humate may be interpreted as humic acid stimulate absorption of nutrients by root, plant photosynthesis and respiration, it consequently may enhance dry matter accumulation in plant organs. This conclusion was also suggested by Maryam (2012) on lettuce.

Table 1. Effect of some organic macro and micro nutrients on growth parameters of three tomato hybrids during 2010/2011 and 2011/2012 seasons

Treatments \ Hybrids	2010/2011 season				2011/2012 season			
	GS-12	TH 99809	NS × 9535	Mean	GS-12	TH 99809	NS × 9535	Mean
				Plant height (cm)				
NPK-humate	80.4^{de}	90.5^{a}	70.3^{h}	80.4^{A}	82.8^{de}	90.8^{a}	72.7^{h}	82.1^{A}
Chelat micro-elements	75.3^{g}	83.4^{cd}	65.5^{j}	74.7^{D}	77.7^{g}	85.8^{cd}	67.9^{j}	77.1^{D}
K-citrate	78.1^{efg}	88.3^{ab}	69.4^{hi}	78.6^{B}	80.5^{efg}	89.0^{ab}	71.8^{hi}	80.4^{B}
Ca-citrate	76.2^{fg}	85.2^{bc}	66.5^{ij}	75.9^{C}	78.5^{fg}	87.6^{bc}	68.9^{ij}	78.3^{C}
Control	70.6^{h}	79.3^{ef}	61.5^{k}	70.5^{E}	72.9^{h}	81.7^{ef}	63.9^{k}	72.8^{E}
Mean	76.1^{B}	85.3^{A}	66.6^{C}		78.5^{B}	86.9^{A}	69.0^{C}	
				Number of branches / plant				
NPK-humate	11.8^{a}	12.0^{a}	10.3^{bcd}	11.4^{A}	12.5^{a}	12.5^{a}	11.0^{bcd}	12.0^{A}
Chelat micro-elements	9.3^{def}	10.3^{bcd}	8.5^{ef}	9.4^{D}	10.0^{def}	11.1^{bcd}	9.3^{ef}	10.1^{D}
K-citrate	11.0^{abc}	11.5^{ab}	9.8^{cde}	10.8^{B}	11.5^{abc}	12.3^{ab}	10.6^{cde}	11.5^{B}
Ca-citrate	10.0^{cd}	10.8^{abc}	9.0^{def}	9.9^{C}	10.7^{cd}	11.6^{abc}	9.7^{def}	10.7^{C}
Control	9.0^{def}	10.0^{cd}	8.0^{f}	9.0^{D}	9.8^{def}	10.7^{cd}	8.0^{f}	9.5^{D}
Mean	10.22^{A}	10.92^{A}	9.12^{A}		10.9^{A}	11.7^{A}	9.7^{A}	
				Number of leaves/ plant				
NPK-humate	24.3^{bcd}	28.3^{a}	18.7^{fgh}	23.8^{A}	27.7^{bcd}	31.7^{a}	22.1^{fgh}	27.2^{A}
Chelat micro-elements	20.0^{efg}	25.3^{abc}	16.3^{hi}	20.5^{C}	23.4^{efg}	28.7^{abc}	19.7^{hi}	23.9^{C}
K-citrate	23.3^{bcde}	26.7^{ab}	17.7^{gh}	22.6^{AB}	26.7^{bcde}	30.1^{ab}	21.1^{gh}	25.9^{AB}
Ca-citrate	21.3^{def}	25.7^{abc}	17.0^{gh}	21.3^{BC}	24.7^{def}	29.1^{abc}	20.4^{gh}	24.7^{BC}
Control	17.6^{gh}	22.0^{cde}	13.7^{i}	17.8^{D}	21.0^{gh}	25.4^{cde}	17.5^{i}	21.3^{D}
Mean	21.3^{B}	25.6^{A}	16.7^{C}		24.7^{B}	29.0^{A}	20.2^{C}	

* Means followed by the same letters are not significantly differed according to LSD at 5% level.

Table 2. Effect of some organic macro and micro nutrients on growth parameters of three tomato hybrids during 2010/2011 and 2011/2012 seasons

Treatments \ Hybrids	2010/2011 season				2011/2012 season			
	GS-12	TH 99809	NS × 9535	Mean	GS-12	TH 99809	NS × 9535	Mean
Leaves fresh weight (g / plant)								
NPK-humate	250.25^{d}	503.20^{a}	243.20^{e}	332.22^{A}	305.75^{d}	558.70^{a}	298.70^{e}	387.72^{A}
Chelat micro-elements	235.30^{f}	245.35^{e}	205.35^{i}	228.67^{D}	290.80^{f}	300.85^{e}	260.85^{i}	284.17^{D}
K-citrate	243.20^{e}	481.40^{b}	242.75^{e}	322.45^{B}	298.70^{e}	536.90^{b}	298.25^{e}	377.95^{B}
Ca-citrate	242.50^{e}	363.25^{c}	207.35^{i}	271.03^{C}	305.75^{e}	558.70^{c}	298.70^{i}	326.53^{C}
Control	220.00^{h}	230.20^{g}	190.20^{j}	213.47^{E}	275.50^{h}	285.70^{g}	245.70^{j}	268.97^{E}
Mean	238.25^{B}	364.68^{A}	217.77^{C}		293.75^{B}	420.18^{A}	273.27^{C}	
Leaves dry weight (g / plant)								
NPK-humate	41.90^{d}	70.50^{a}	35.95^{efgh}	49.45^{A}	44.70^{d}	73.30^{a}	38.75^{efgh}	52.25^{A}
Chelat micro-ellements	36.75^{efg}	41.35^{d}	34.00^{gh}	37.37^{D}	35.55^{efg}	44.15^{d}	36.80^{gh}	40.17^{D}
K-citrate	40.20^{de}	60.93^{b}	35.16^{fgh}	45.43^{B}	43.00^{de}	63.73^{b}	37.96^{fgh}	48.23^{B}
Ca-citrate	39.80^{de}	50.75^{c}	34.35^{fgh}	41.63^{C}	42.60^{de}	53.55^{c}	37.15^{fgh}	44.43^{C}
Control	34.50^{fgh}	38.35^{def}	32.30^{h}	35.05^{E}	37.30^{fgh}	41.15^{def}	35.10^{h}	32.85^{E}
Mean	38.63^{B}	52.38^{A}	34.35^{C}		41.43^{B}	55.18^{A}	37.15^{C}	
Stems fresh weight (g / plant)								
NPK-humate	195.30^{c}	229.63^{a}	95.20^{i}	173.38^{A}	217.50^{c}	251.83^{a}	117.40^{i}	195.98^{A}
Chelat micro-elements	150.50^{h}	157.44^{fg}	80.20^{j}	129.38^{D}	172.70^{h}	179.64^{fg}	102.40^{j}	151.58^{D}
K-citrate	185.80^{d}	215.00^{b}	92.50^{i}	164.43^{B}	208.00^{d}	237.20^{b}	114.70^{i}	186.63^{B}
Ca-citrate	160.35^{f}	166.36^{e}	81.95^{j}	136.22^{C}	182.55^{f}	188.56^{e}	104.15^{j}	158.42^{C}
Control	148.90^{h}	156.40^{g}	80.00^{j}	128.43^{D}	171.10^{h}	178.60^{g}	102.20^{j}	150.63^{D}
Mean	168.17^{B}	184.97^{A}	85.97^{C}		190.37^{B}	207.17^{A}	108.17^{C}	
Stems dry weight (g / plant)								
NPK-humate	48.07^{cd}	59.49^{a}	39.64^{g}	49.07^{A}	50.27^{cd}	61.69^{a}	41.84^{g}	51.27^{A}
Chelat micro-elements	40.63^{fg}	50.75^{bc}	32.50^{ij}	41.29^{D}	42.83^{fg}	52.95^{bc}	34.70^{ij}	43.49^{D}
K-citrate	45.86^{de}	55.88^{ab}	36.69^{h}	46.14^{B}	48.06^{de}	58.08^{ab}	38.89^{h}	48.34^{B}
Ca-citrate	43.30^{ef}	53.05^{b}	35.05^{hi}	43.80^{C}	45.50^{ef}	55.25^{b}	37.25^{hi}	46.00^{C}
Control	39.03^{g}	49.15^{c}	30.90^{j}	39.69^{D}	41.23^{g}	51.35^{c}	33.10^{j}	41.89^{D}
Mean	43.38^{B}	53.66^{A}	34.96^{C}		45.58^{B}	55.86^{A}	37.16^{C}	

* Means followed by the same letters are not significantly differed according to LSD at 5% level.

Table 3. Effect of some organic macro and micro nutrients on growth parameters of three tomato hybrids during 2010/2011 and 2011/2012 seasons

Treatments \ Hybrids	2010/2011 season				2011/2012 season			
	GS-12	TH 99809	NS × 9535	Mean	GS-12	TH 99809	NS × 9535	Mean
				Roots fresh weight (g / plant)				
NPK-humate	18.37^{abc}	20.20^{a}	15.93^{cdef}	18.70^{A}	19.57^{abc}	21.40^{a}	17.13^{cdef}	19.37^{A}
Chelat micro-elements	14.59^{defg}	16.95^{bcde}	12.23^{g}	14.59^{D}	15.79^{defg}	18.15^{bcde}	13.43^{g}	15.79^{D}
K-citrate	17.40^{abcd}	19.04^{ab}	14.16^{efg}	16.87^{B}	18.60^{abcd}	20.24^{ab}	15.36^{efg}	18.07^{B}
Ca-citrate	16.95^{bcde}	18.00^{abc}	13.20^{fg}	16.05^{C}	18.15^{bcde}	19.20^{abc}	14.40^{fg}	17.25^{C}
Control	14.00^{fg}	16.00^{cdef}	12.00^{g}	14.00^{D}	15.20^{fg}	16.35^{cdef}	13.20^{g}	15.20^{D}
Mean	16.26^{B}	18.04^{A}	13.50^{C}		17.46^{B}	19.24^{A}	14.70^{C}	
				Roots dry weight (g / plant)				
NPK-humate	7.19^{bcd}	9.75^{a}	6.23^{cd}	7.72^{A}	7.94^{bcd}	10.50^{a}	6.98^{cd}	8.47^{A}
Chelat micro-elements	6.25^{cd}	7.30^{bcd}	5.15^{d}	6.23^{B}	7.00^{cd}	8.05^{bcd}	5.90^{d}	6.98^{B}
K-citrate	7.12^{bcd}	9.05^{ab}	6.03^{d}	7.40^{A}	7.87^{bcd}	9.80^{ab}	6.78^{d}	8.15^{A}
Ca-citrate	6.84^{bcd}	8.38^{abc}	5.98^{d}	7.07^{A}	7.59^{bcd}	9.13^{abc}	6.73^{d}	7.82^{A}
Control	6.00^{d}	7.00^{bcd}	5.00^{d}	6.00^{B}	6.95^{d}	7.75^{bcd}	5.00^{d}	6.57^{B}
Mean	6.68^{B}	8.30^{A}	5.68^{C}		7.47^{B}	9.05^{A}	6.28^{C}	
				Root length (cm)				
NPK-humate	31.50^{ab}	32.90^{a}	28.90^{def}	31.10^{A}	32.30^{ab}	33.70^{a}	29.70^{def}	31.90^{A}
Chelat micro-elements	30.00^{bcde}	30.70^{abcd}	26.20^{gh}	28.90^{C}	30.80^{bcde}	31.50^{abcd}	27.00^{gh}	29.80^{C}
K-citrate	31.00^{abc}	32.00^{ab}	28.00^{efg}	30.30^{AB}	32.00^{abc}	32.80^{ab}	28.80^{efg}	31.20^{AB}
Ca-citrate	30.90^{abcd}	31.40^{ab}	27.50^{fg}	29.90^{B}	31.70^{abcd}	32.20^{ab}	28.30^{fg}	30.70^{B}
Control	28.00^{efg}	29.00^{cdef}	25.00^{h}	27.30^{D}	28.90^{efg}	29.90^{cdef}	25.80^{h}	28.20^{D}
Mean	30.28^{A}	31.20^{A}	27.12^{B}		31.10^{A}	32.00^{A}	27.9^{B}	

* Means followed by the same letters are not significantly differed according to LSD at 5% level.

As the positively effect of K-citrate on plant growth, similar results were obtained by Synsuke *et al.* (2011) on tomato. Results could be easily explained as potassium is well-known to enhance photosynthesis, thereby, it could increase dry matter accumulation in plant organs. The relationship between potassium and photosynthetic rate in tomato was reported by Synsuke *et al.* (2011).

Root length was also positively responded to NPK-humate. In this connection, K-citrate came at the second rank followed by Ca-citrate and chelated micro-nutrients as control occupied the last rank. Humates was also reported to increase tomato root growth (Norman *et al.*, 2003). Another confirmation was done by Lulakis and Petsas (1995) who found that humic substances were beneficial to root length of tomato.

The positive effect of Ca-citrate on root growth may be a result of increasing photosynthesis and carbohydrate accumulation in plant organs. This conclusion was also suggested by Synsuke *et al.* (2011) on tomato.

The noticed insignificant effect of chelated micro-nutrients on studied growth parameters may be a result of existing enough amounts of these nutrients in the soil. This conclusion goes along with the results of Cengiz and David (2002) who found that high levels of Zn and Fe showed a significant decrease in the production of dry matter and chlorophyll contents of tomato.

The three studied tomato hybrids significantly differed in leaves, stems, roots fresh and dry weights as well as root length (Tables 2 and 3). TH 99809 hybrid showed superior records in all of the above mentioned growth parameters. It was followed by GS-12 hybrid as NPK-occupied the last position.

The variation among cultivars in their growth was also suggested by Ramakumar *et al.*, (1981) and Coltman (1983) to be due to variations in nutrients use efficiency and heritability genes. Another confirmation was done by Kleinkopf *et al.*, (1981) who reported varietal variation in the potentially of dry matter accumulation.

As for the interaction effect, data in Tables 2 and 3 show that TH 99809 hybrid receiving NPK-humates was of pioneer position in all tested growth parameters.

Leaf area/ plant

Comparing to control, all the tested treatments increased leaf area/ plant, moreover, NPK-humates attained the highest record (Table 4). This result hold true in both growing seasons. NPK-humates was followed by K-citrate, Ca-citrate, chelated micro-nutrient and control.

Obtained results coincide with those of Norman *et al.* (2003) who found that humates increased leaf area of pepper plants. Another confirmation was done by Inaki *et al.* (2011) on pepper.

The increase in leaf area may be a result of increasing chlorophyll, nutrients content and photosynthesis, factors that may be positively reflected on leaf area.

Besides, the known fact of nitrogen incorporation in chlorophyll of leaves which is responsible for the photosynthesis process known to be the base of synthesis of all organic substances in plant, factor that may reflected on leaf area. This conclusion was also suggested by Midan (1972) on beans.

The positive effect of K-citrate on leaf area may be explained as K favoured photosynthesis, leaf water potential and leaf transpiration rate, factors that favourably affected leaf area. Synsuke *et al.* (2011) drawn similar conclusion.

The studied hybrids varied in leaf area as TH 99809 hybrid achieved the highest record followed by GS-12 as NSX came at the last position (Table 4). Again growth criteria of plants are controlled by heriditical genes.

As for the interaction, TH 99809 hybrid receiving NPK-humates exhibited the highest leaf area value (Table 4). It could be easily concluded from such data that NS × 9535 hybrid failed to exhibit superior records under all of the applied nutrients.

Biochemical Constituents in Leaves

Total sugars

Ca-citrate and K-citrate exhibited significant increases in total sugars content in tomato leaves (Table 5). In this connection, the lowest

Table 4. Effect of some organic macro and micro nutrients on leaf area (cm^2/plant) of three tomato hybrids during 2010/2011 and 2011/2012 seasons

Treatments \ Hybrids	2010/2011 season				2011/2012 season			
	GS-12	TH 99809	NS × 9535	Mean	GS-12	TH 99809	NS × 9535	Mean
	Leaf area (cm^2 / plant)							
NPK-humate	2380.0^{e}	2795.0^{a}	2065.0^{i}	2413.3^{A}	2452.0^{e}	2867.0^{a}	2173.0^{i}	2485.3^{A}
Chelat micro-elements	2066.0^{i}	2410.0^{d}	1953.0^{m}	2143.0^{D}	2138.0^{i}	2482.0^{d}	2025.0^{m}	2215.0^{D}
K-citrate	2310.0^{g}	2571.0^{b}	2020.0^{j}	2300.0^{B}	2382.0^{g}	2643.0^{b}	2092.0^{j}	2372.3^{B}
Ca-citrate	2096.0^{h}	2510.0^{c}	1995.0^{l}	2200.3^{C}	2168.0^{h}	2582.0^{c}	2067.0^{l}	2272.3^{C}
Control	2011.0^{k}	2355.0^{f}	1898.0^{n}	2088.0^{E}	2083.0^{k}	2427.0^{f}	1970.0^{n}	2160.0^{E}
Mean	2172.6^{B}	2528.2^{A}	1986.2^{C}		2244.6^{B}	2600.2^{A}	2058.2^{C}	

* Means followed by the same letters are not significantly differed according to LSD at 5% level.

Table 5. Effect of some organic macro and micro nutrients on biochemical constituents in leaves of three tomato hybrids during 2010/2011 and 2011/2012 seasons

Treatments \ Hybrids	2010/2011 season				2011/2012 season			
	GS-12	TH 99809	NS × 9535	Mean	GS-12	TH 99809	NS × 9535	Mean
	Total sugars in leaves (mg / g d.wt)							
NPK-humate	8.50^{ab}	9.00^{a}	8.30^{ab}	8.60^{B}	8.90^{ab}	9.40^{a}	8.70^{ab}	9.00^{B}
Chelat micro-elements	8.70^{ab}	9.10^{a}	7.50^{c}	8.40^{B}	9.10^{ab}	9.50^{a}	7.90^{c}	8.80^{B}
K-citrate	9.10^{a}	9.50^{a}	8.90^{ab}	9.20^{A}	9.50^{a}	9.90^{a}	9.30^{ab}	9.60^{A}
Ca-citrate	9.80^{a}	10.90^{a}	8.70^{a}	9.80^{A}	10.20^{a}	11.30^{a}	9.10^{a}	10.20^{A}
Control	7.70^{c}	8.50^{ab}	7.10^{c}	7.80^{C}	8.10^{c}	8.90^{ab}	7.50^{c}	8.20^{C}
Mean	8.80^{B}	9.40^{A}	8.10^{B}		9.20^{B}	9.80^{A}	8.50^{B}	
	Total free amino acids (mg / g d.wt)							
NPK-humate	25.90^{ab}	26.40^{a}	25.30^{ab}	25.90^{A}	26.40^{ab}	26.90^{a}	25.80^{ab}	26.40^{A}
Chelat micro-elements	25.10^{ab}	25.90^{ab}	25.00^{ab}	25.30^{A}	25.60^{ab}	26.40^{ab}	25.50^{ab}	25.80^{A}
K-citrate	24.50^{abc}	25.50^{ab}	24.10^{abc}	24.70^{B}	25.00^{abc}	25.90^{ab}	24.60^{abc}	25.20^{B}
Ca-citrate	24.90^{abc}	25.90^{ab}	24.50^{abc}	25.10^{A}	25.40^{abc}	26.40^{ab}	25.00^{abc}	25.60^{A}
Control	22.00^{bc}	23.00^{abc}	21.00^{c}	22.00^{C}	24.50^{bc}	25.50^{abc}	23.50^{c}	24.50^{C}
Mean	24.50^{B}	25.30^{A}	24.00^{B}		25.40^{B}	26.20^{A}	24.90^{B}	

* Means followed by the same letters are not significantly differed according to LSD at 5% level.

value was obtained in check plants. The role of potassium in photosynthesis and sugars translocation in tomato was reported by Bishnu and Zeev (2004) and Synsuke *et al.* (2011).

It is worthwhile to mention that, the tested tomato hybrids differed in the total sugars content (Table 5). TH 99809 hybrid showed the highest record (Table 5). Results may be explained as the biochemical constituents of plant organs are dependent on hereditical factors.

As for the interaction effects, TH 99809 hybrid interacted with Ca-citrate give the highest total sugars content in leaves (Table 5). The lowest record, in this connection, being obtained from NS × 9535 hybrid receiving chelat micro-elements.

Total free amino acids:

Comparing to control, all of the tested treatments gave significant increases in total free amino acids in leaves (Table 5). In this connection, NPK-humates achieved the highest record followed descendingly by chelated micronutrients and Ca-citrate. This result hold true in both seasons.

Results could be explained on the base of increasing nitrogen absorption and consequently it's assimilation by plants. This suggestion matched well with that of Maryam (2012) on tomato.

Such micronutrients, i.e., Zn, Fe and Mn, were also reported by El-Sayed *et al.* (2010) to augment total free amino acids in onion leaves.

As for the free amino acids in the studied tomato hybrids, data in Table 5 show that TH 99809 hybrid are of the highest record in this regard followed by GS-12 and NS × 9535 hybrids. Results could be interpreted as a variation in N uptake, the important element in amino acids synthesis.

As for the interacted effect, TH 99809 hybrid receiving chelated micro-nutrients exhibited superior total free amino acids record.

N, P and K contents in plant leaves

As it could be seen from such data, NPK-humates showed significant increases in N and P contents of plant leaves as compared to control (Table 6). Chelated micro-nutrients showed also significant increases in P content. However, K-citrate caused significant increase in K content, followed by NPK-humates.

Results may be discussed as humates encourage nutrients uptake by plants.

Similar conclusion was previously drawn by Bohme and Thi-Lau (1997) who reported that humic acid had beneficial effects on P and K uptake by tomato plants. Further confirmation was done by Maryam (2012) who found that humic acid stimulate nutrients absorption by roots. Obtained results go along with those of Hasanein (2011) on tomato.

The highest value of NPK contents comparing to the other tested hybrids was recorded by TH 99809 hybrid (Table 6). This result goes along with those of Hernandez *et al.* (2007) who reported that elements content of tomato plants seemed more influenced by the cultivar.

TH 99809 hybrid receiving NPK-humate showed superior N and P contents in leaves (Table 6). Also, it exhibited the highest K contents when plants receiving K-citrate.

N, P and K utilization quotient

The efficiency of elements utilization can be expressed through the relation between dry weight produced by plant and the element absorbed, also, by plant.

It could be detected from such data presented in Table 7 that plants received K-citrate are of pioneer position in N and P utilization quotient. It was followed, with slight discrepancies, by those received Ca-citrate. Also, the highest value of K-utilization quotient being obtained in plants received Ca-citrate.

Results could be discussed as treatments of lowest leaves dry weight or those of less element concentration in leaves showed, in general, superior values of element utilization quotient. Vice versa is true, i.e., plants of high leaves dry weight or those of high element concentration are of inferior element utilization quotient. Results appeared logic as this index, element utilization quotient, was calculated by dividing one by leaves dry weight multiplied in element concentration. Thus, the reduction of denominator (the root of the fraction) lead to an increase in the produced value and vice versa in true. This conclusion was previously suggested by Midan (2003) on pepper.

Table 6. Effect of some organic macro and micro nutrients on N, P and K contents in leaves of three tomato hybrids during 2010/2011 and 2011/2012 seasons

Treatments \ Hybrids	2010/2011 season				2011/2012 season			
	GS-12	TH 99809	NS × 9535	Mean	GS-12	TH 99809	NS × 9535	Mean
				N (g / 100 g d.wt)				
NPK-humate	4.10^{ab}	4.50^{a}	3.90^{ab}	4.17^{A}	4.90^{ab}	5.30^{a}	4.70^{ab}	4.97^{A}
Chelat micro-elements	3.80^{ab}	4.10^{ab}	3.50^{ab}	3.80^{B}	4.60^{ab}	4.90^{ab}	4.30^{ab}	4.60^{B}
K-citrate	2.90^{ab}	3.00^{ab}	2.50^{b}	2.80^{D}	3.70^{ab}	3.80^{ab}	3.30^{b}	3.60^{D}
Ca-citrate	3.00^{ab}	3.80^{ab}	2.80^{b}	3.20^{C}	3.82^{ab}	4.60^{ab}	3.60^{b}	4.01^{C}
Control	$2. 08^{b}$	3.01^{ab}	2.07^{b}	2.39^{E}	3.06^{b}	3.09^{ab}	3.05^{b}	3.07^{E}
Mean	3.32^{B}	3.70^{A}	3.08^{C}		4.12^{B}	4.50^{A}	3.88^{C}	
				P (g / 100 g d.wt)				
NPK-humate	2.20^{ab}	2.50^{a}	2.10^{abc}	2.27^{A}	2.90^{ab}	3.20^{a}	2.80^{abc}	2.97^{A}
Chelat micro-elements	1.80^{abc}	1.90^{abc}	1.70^{abc}	1.80^{B}	2.50^{abc}	2.60^{abc}	2.40^{abc}	2.50^{B}
K-citrate	1.10^{bc}	1.30^{abc}	0.95^{bc}	1.12^{D}	1.80^{bc}	2.00^{abc}	1.65^{bc}	1.82^{D}
Ca-citrate	1.50^{abc}	1.70^{abc}	1.30^{abc}	1.50^{C}	2.20^{abc}	2.40^{abc}	2.00^{abc}	2.20^{C}
Control	0.90^{c}	1.10^{bc}	0.85^{c}	0.95^{E}	1.60^{c}	1.80^{bc}	1.55^{c}	1.65^{E}
Mean	1.50^{A}	1.70^{A}	1.38^{A}		2.20^{A}	2.40^{A}	2.08^{A}	
				K (g / 100 g d.wt)				
NPK-humate	6.10^{ab}	6.30^{ab}	6.00^{ab}	6.13^{B}	6.92^{ab}	7.12^{ab}	6.82^{ab}	6.95^{B}
Chelat micro-elements	5.50^{abc}	5.80^{abc}	5.10^{abc}	5.47^{C}	6.32^{abc}	6.62^{abc}	5.92^{abc}	6.29^{C}
K-citrate	7.02^{a}	7.32^{a}	7.00^{a}	7.11^{A}	7.84^{a}	8.14^{a}	7.00^{a}	7.93^{A}
Ca-citrate	5.10^{abc}	5.30^{abc}	4.80^{cd}	5.07^{D}	5.92^{abc}	6.12^{abc}	5.62^{cd}	5.89^{D}
Control	4.70^{cd}	4.80^{cd}	4.50^{cd}	4.67^{E}	5.52^{cd}	5.62^{cd}	5.32^{cd}	5.49^{E}
Mean	5.68^{A}	5.90^{A}	5.48^{A}		6.50^{A}	6.72^{A}	6.30^{A}	

* Means followed by the same letters are not significantly differed according to LSD at 5% level.

Table 7. Effect of some organic macro and micro nutrients on N, P and K utilization quotient of three tomato hybrids during 2010/2011 and 2011/2012 seasons

Treatments \ Hybrids	2010/2011 season				2011/2012 season			
	GS-12	TH 99809	NS × 9535	Mean	GS-12	TH 99809	NS × 9535	Mean
				N utilization quotient				
NPK-humate	12.32^{de}	12.37^{de}	11.96^{ef}	12.22^{C}	10.36^{de}	10.55^{de}	10.03^{ef}	10.31^{C}
Chelat micro-elements	12.67^{gh}	11.09^{fgh}	10.71^{gh}	11.49^{C}	10.60^{gh}	11.01^{fgh}	10.56^{gh}	10.72^{C}
K-citrate	13.86^{cd}	20.31^{a}	14.06^{c}	16.08^{A}	11.62^{cd}	16.77^{a}	11.50^{c}	13.30^{A}
Ca-citrate	13.97^{cd}	18.55^{b}	12.84^{cde}	15.12^{B}	11.70^{cd}	15.93^{b}	10.76^{cde}	12.80^{B}
Control	9.71^{gh}	11.28^{efg}	8.81^{h}	9.93^{D}	8.69^{gh}	10.10^{efg}	7.90^{h}	8.90^{D}
Mean	12.51^{B}	14.72^{A}	11.68^{B}		10.59^{B}	12.87^{A}	10.15^{B}	
				P utilization quotient				
NPK-humate	27.93^{e}	41.47^{b}	27.65^{e}	32.35^{C}	23.31^{bc}	22.86^{d}	22.65^{bc}	22.94^{C}
Chelat micro-elements	20.42^{f}	21.76^{f}	20.00^{f}	20.73^{D}	15.82^{f}	16.98^{f}	15.33^{f}	16.04^{D}
K-citrate	36.55^{cd}	46.87^{a}	37.01^{cd}	40.14^{A}	23.89^{cd}	31.87^{a}	23.01^{cd}	26.26^{A}
Ca-citrate	38.33^{bc}	34.86^{d}	38.00^{bc}	37.06^{B}	20.32^{e}	30.54^{b}	19.38^{e}	23.41^{B}
Control	18.09^{fg}	20.30^{f}	16.36^{g}	18.25^{E}	14.69^{fg}	16.73^{f}	13.27^{g}	14.90^{E}
Mean	28.26^{B}	33.05^{A}	27.80^{C}		19.61^{B}	23.80^{A}	18.73^{C}	
				K utilization quotient				
NPK-humate	6.52^{abc}	8.06^{ab}	5.73^{abc}	6.77^{B}	6.16^{ab}	7.52^{ab}	5.45^{abc}	6.38^{B}
Chelat micro-elements	6.68^{abc}	7.13^{ab}	6.67^{abc}	6.83^{B}	6.26^{abc}	6.67^{ab}	6.22^{abc}	6.38^{B}
K-citrate	7.34^{ab}	7.99^{ab}	7.18^{ab}	7.50^{B}	6.76^{ab}	7.32^{ab}	6.60^{ab}	6.89^{B}
Ca-citrate	8.22^{ab}	13.30^{a}	7.49^{ab}	9.67^{A}	7.65^{ab}	11.98^{a}	6.90^{ab}	8.81^{A}
Control	4.34^{ab}	7.99^{ab}	4.18^{ab}	5.50^{C}	4.76^{ab}	6.32^{ab}	3.60^{ab}	4.89^{C}
Mean	6.62^{B}	8.89^{A}	6.25^{B}		6.32^{B}	7.96^{A}	5.75^{C}	

* Means followed by the same letters are not significantly differed according to LSD at 5% level.

Another explanation could be done as potassium increased photosynthesis intensity and carbohydrate accumulation, thereby, it could enhance elements utilization quotient. The relationship between carbohydrate content and minerals utilization quotient was previously recorded by Khalil (1990) on tomato.

The generally unfavourable effect of such treatments on elements utilization quotient could be explained on the same base of increasing leaves dry weight and / or element content in leaves. Midan (1972) on bean and Midan *et al.* (1989) on potato came to similar conclusion.

The tested tomato hybrids varied in elements utilization quotient (Table 7) TH 99809 hybrid evidently gained the highest record in all elements utilization quotient. The efficiency of elements utilization seemed to be dependent on hereditical factors.

The cultivars variation in nutrients use efficiency was also noticed by Ramakumar *et al.* (1981) and Coltman (1983). They attributed the cultivars variation to be due to variation in hereditical genes.

Genotypical differences in nutrient efficiency occur for a number of reasons, these being related to uptake, transport and utilization within plants.

There are typical differences in nitrogen requirement at the cellular level, for example, between C_3 and C_4 species, factor that may affect it's use efficiency. English and Barker (1987) came to similar conclusion. Besides, for phosphorus higher use efficiency in certain genotypes may be related to better use of stored P either within a given tissue or by better retranslocation between shoot organs as suggested by Riley *et al.* (1993).

In the case of potassium use efficiency genotypical differences in potential potassium replacement, play a major role. The suggested interpretion was previously reported by Graham (1984).

As for the interaction between studied tomato hybrids and applied organic nutrients, it is obviously clear that TH 99809 hybrid achieved the highest record in all studied elements utilization quotient when K-citrate was added (Table 7).

Chlorophyll a, b and carotenoids

NPK-humates caused superior values in all studied chlorophyll fractions content (Fig. 1). It was followed by K-citrate.

Results could be interpreted as nitrogen involved in chlorophyll molecule, thus its positive effect in this connection is reasonable. Besides, potassium was previously reported by Bishnu and Zeev (2004) to favour total chlorophyll in tomato leaves.

Results revealed significant differences between the tested hybrids in chlorophyll fractions (Fig. 1). TH 99809 hybrid seems to be of the highest contents in this regard.

The chemical constituents of plants being dependent on hereditical genes.Obtained results matched well with those of Cengiz and David (2002) on tomato. They reported that there were significant differences between the cultivars in chlorophyll content. They added that, there were an inherent differences in response between the cultivars.

Results concerning the interaction between studied factors indicate that TH 99809 hybrid being of superior chlorophyll record when plants received NPK-humates (Fig. 1).

Biochemical Constituents of Fruits

NO_3 accumulation in fruits

The highest value of NO_3 accumulation in fruits was noticed in plants received NPK-humates (Fig. 2). Those received K-citrate and Ca-citrate came in the second and third position,respectively, as control plants occupied the latest position.

Results could be explained as a result of increasing N-uptake and assimilation. Obtained results coincided with those of Maryam (2012) on lettuce who reported that NO_3 concentration increased in treatments supplemented with humic acid.

GS-12 hybrid exhibited superior value of NO_3 accumulation in fruits as TH 99809 hybrid came in the second rank (Fig. 2).

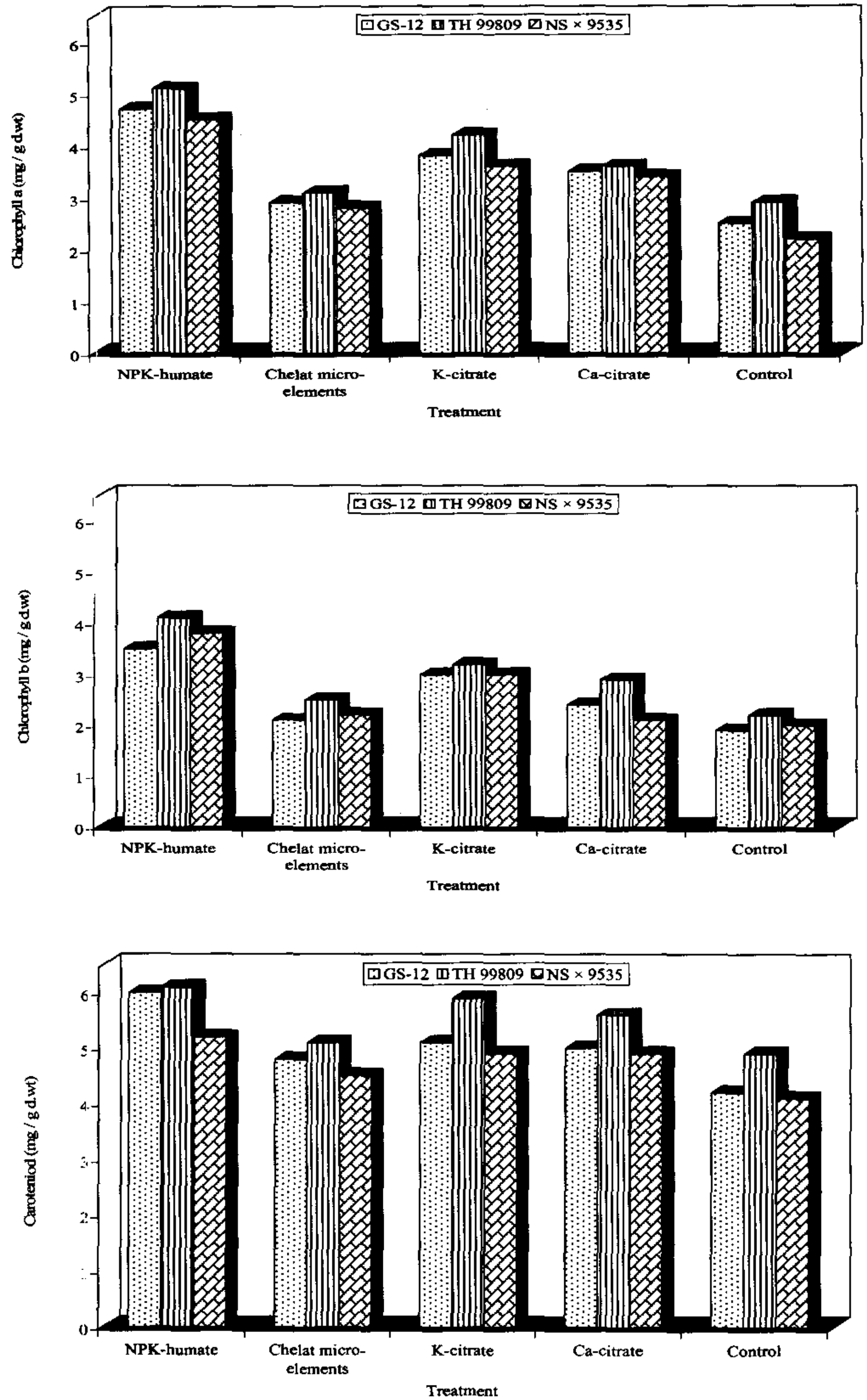

Fig. 1. Effect of some organic macro and micro nutrients on chlorophyll a, b and carotenoids contents of three tomato hybrids

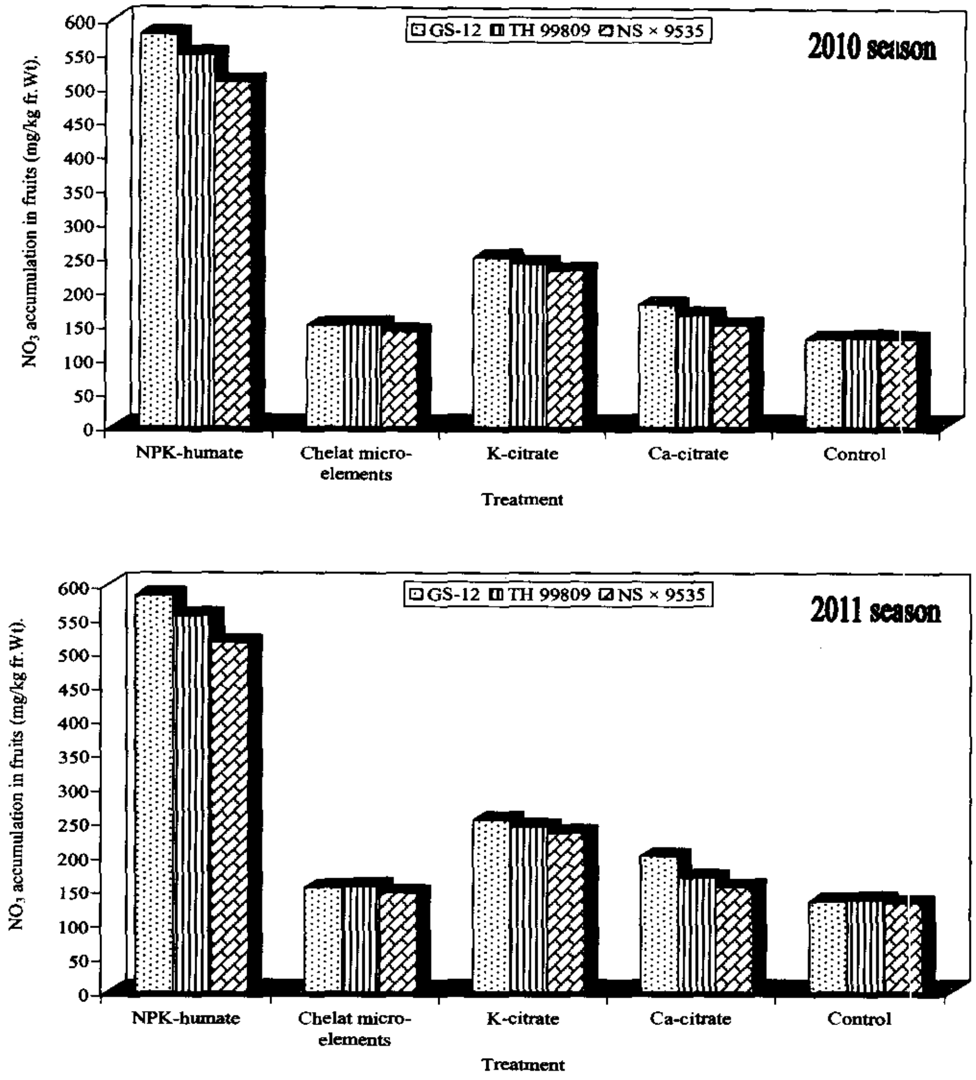

Fig. 2. Effect of some organic macro and micro nutrients on NO_3 accumulation in fruits (mg/kg fr.wt) of three tomato hybrids during 2010/2011 and 2011/2012 seasons

The cultivars differences in chemical constituents were also noticed by Cengiz and David (2002) who reported that the differences indicated an inherent differences in response among the cultivars.

As for the interaction, GS-12 showed the highest values of NO_3 accumulation in fruits when plants received NPK-humates (Fig. 2).

Total soluble solids and vitamin C in fruits

Ca-citrate and chelated micro-nutrients exhibited superior T.S.S and vitamin C contents in tomato fruits (Table 8). Besides, control plants achieved the lowest values in this respect.

Ca-citrate and chelated micro-nutrients activate photosynthesis and assimilates accumulation that may explain their positive effect on T.S.S and vitamin C contents in fruit. In addition, the effective role of such micro-nutrients in controlling various enzymes activities and photosynthetic pigments formation may explain their positive effect in this regard. Similar conclusion was previously drawn by Abou El-Khair *et al.* (2011) working on garlic. Results could be interpreted also as the assimilation of carbohydrates enhanced vitamin C synthesis.

Table 8. Effect of some macro and micro organic nutrients on total soluble solids in fruits (%) and vitamin C in fruits (mg / 100 g fw) of three tomato hybrids during 2010/2011 and 2011/2012 seasons

Hybrids	2010/2011 season				2011/2012 season			
Treatments	GS-12	TH 99809	NS × 9535	Mean	GS-12	TH 99809	NS × 9535	Mean
				Total soluble solids in fruits (%)				
NPK-humate	6.12^{bc}	5.85^{cd}	5.40^{cd}	5.79^{B}	4.82^{bc}	4.55^{cd}	4.10^{cd}	4.49^{B}
Chelat micro-elements	7.30^{ab}	6.83^{bc}	7.30^{ab}	7.14^{A}	6.00^{ab}	5.53^{bc}	6.00^{ab}	5.84^{A}
K-citrate	6.03^{bc}	5.20^{cd}	6.23^{bc}	5.82^{B}	4.73^{bc}	3.90^{cd}	4.93^{bc}	4.52^{B}
Ca-citrate	8.00^{a}	8.35^{a}	7.53^{ab}	7.96^{A}	6.70^{a}	7.05^{a}	6.23^{ab}	6.66^{A}
Control	4.20^{d}	4.35^{d}	4.00^{d}	4.18^{C}	3.90^{d}	4.05^{d}	3.70^{d}	3.88^{C}
Mean	6.33^{A}	6.12^{A}	6.09^{B}		5.23^{A}	5.02^{A}	4.99^{B}	
				Vitamin C in fruits (mg / 100 g fr.wt)				
NPK-humate	28.92^{def}	29.74^{de}	28.75^{def}	29.14^{C}	27.62^{def}	28.44^{de}	27.45^{def}	27.84^{C}
Chelat micro-elements	31.78^{bc}	32.70^{ab}	29.36^{de}	31.28^{B}	30.48^{bc}	31.40^{ab}	28.06^{de}	29.98^{B}
K-citrate	28.04^{efg}	29.56^{de}	28.56^{ef}	28.72^{C}	26.74^{efg}	28.26^{de}	27.26^{ef}	27.42^{C}
Ca-citrate	32.88^{ab}	33.65^{a}	30.02^{cd}	32.18^{A}	31.58^{ab}	32.35^{a}	28.72^{cd}	30.88^{A}
Control	27.00^{fg}	27.95^{fg}	26.87^{g}	27.27^{D}	25.70^{fg}	26.65^{fg}	25.57^{g}	25.97^{D}
Mean	29.72^{B}	30.72^{A}	28.71^{C}		28.42^{B}	29.42^{A}	27.41^{C}	

* Means followed by the same letters are not significantly differed according to LSD at 5% level.

As for the studied hybrids, GS-12 approved to be of the highest T.S.S contents in fruits, since TH 99809 followed it, with insignificant differences. However, TH 99809 came in the first rank regarding vitamin C contents, as it was followed by GS-12.

As previously discussed, the chemical constituents of plant organs appeared to be dependent on the capability of plants to absorb nutrients from the soil that controlled by hereditical genes.

As for the interaction, TH 99809 hybrid achieved superior contents of both T.S.S and vitamin C in fruits of tomato plant receiving Ca-citrate. Besides, somewhat superiority in T.S.S and vitamin C content was noticed in GS-12 when plants received Ca-citrate.

Yield and Yield Components

Number of fruits and average fruit weight

Comparing to control or the other tested treatments, NPK-humates exerted significant increases in both number of fruits / plant and average fruit weight (Table 9). It was followed by K-citrates as chelated micro-nutrients and Ca-citrate came at the third and forth position, respectively.

This result coincided with those of Maryam (2012). Results could be interpreted as humates stimulate root absorption of nutrients, factor that may positively reflected on plant yielding. Number of fruits and average fruit weight of tomato were also reported by Hasanein (2011) to positively respond to NPK application.

Table 9. Effect of some organic macro and micro nutrients on yield and its components of three tomato hybrids during 2010/2011 and 2011/2012 seasons

Treatments \ Hybrids	2010/2011 season				2011/2012 season			
	GS-12	TH 99809	NS × 9535	Mean	GS-12	TH 99809	NS × 9535	Mean
	Number of fruits / plant							
NPK-humate	39.00^{ab}	41.13^{a}	26.90^{e}	35.68^{A}	40.57^{ab}	42.68^{a}	28.45^{e}	37.73^{A}
Chelat micro-elements	30.35^{e}	32.30^{de}	22.58^{g}	28.41^{D}	31.90^{e}	33.85^{de}	24.13^{g}	29.96^{D}
K-citrate	30.45^{e}	32.63^{de}	22.80^{g}	28.63^{D}	32.00^{e}	34.18^{de}	24.35^{g}	30.18^{D}
Ca-citrate	36.20^{c}	40.50^{a}	26.10^{f}	34.27^{B}	37.75^{c}	42.05^{a}	27.65^{f}	35.82^{B}
Control	34.80^{cd}	36.37^{bc}	25.00^{fg}	32.06^{C}	36.35^{cd}	37.92^{bc}	26.50^{fg}	33.61^{C}
Mean	34.16^{A}	36.59^{A}	24.68^{B}		35.71^{A}	38.14^{A}	26.23^{B}	
	Average fruit weight (g)							
NPK-humate	83.81^{abc}	86.76^{a}	76.88^{fg}	82.48^{A}	84.31^{abc}	87.26^{a}	77.38^{fg}	82.98^{A}
Chelat micro-elements	76.75^{fg}	83.20^{bcd}	73.30^{hi}	77.75^{C}	77.25^{fg}	83.70^{bcd}	73.80^{hi}	78.25^{C}
K-citrate	79.16^{ef}	82.81^{bcd}	74.75^{gh}	78.91^{BC}	79.66^{ef}	83.31^{bcd}	75.25^{gh}	79.41^{BC}
Ca-citrate	80.64^{cde}	84.44^{ab}	75.36^{gh}	80.15^{B}	81.14^{cde}	84.94^{ab}	75.86^{gh}	80.65^{B}
Control	73.10^{hi}	80.20^{def}	70.35^{i}	74.55^{D}	73.60^{hi}	80.70^{def}	70.85^{i}	75.05^{D}
Mean	78.69^{B}	83.48^{A}	74.13^{C}		79.19^{B}	83.98^{A}	74.63^{C}	
	Early yield (ton / fed.)**							
NPK-humate	11.86^{abc}	12.90^{a}	5.82^{fg}	10.19^{A}	12.58^{abc}	13.62^{a}	6.54^{fg}	10.91^{A}
Chelat micro-elements	9.05^{de}	10.93^{bcd}	4.42^{gh}	8.13^{C}	9.77^{de}	11.65^{bcd}	5.14^{gh}	8.85^{C}
K-citrate	10.92^{bcd}	12.00^{ab}	5.02^{fgh}	9.31^{B}	11.64^{bcd}	12.75^{ab}	5.74^{fgh}	10.03^{B}
Ca-citrate	8.35^{e}	10.10^{cd}	3.92^{h}	7.46^{D}	9.07^{e}	10.82^{cd}	6.64^{h}	8.18^{D}
Control	6.64^{f}	8.28^{e}	1.38^{i}	5.43^{E}	7.36^{f}	9.00^{e}	2.10^{i}	6.15^{E}
Mean	9.36^{B}	10.84^{A}	4.11^{C}		10.08^{B}	11.56^{A}	4.83^{C}	
	Total yield (ton / fed.)							
NPK-humate	21.82^{ab}	22.95^{a}	19.90^{bcde}	21.56^{A}	24.18^{ab}	25.31^{a}	22.26^{bcde}	23.92^{A}
Chelat micro-elements	19.35^{bcde}	20.54^{abcd}	17.42^{de}	19.10^{BC}	21.71^{bcde}	22.90^{abcd}	19.78^{de}	21.46^{BC}
K-citrate	20.20^{bcde}	21.78^{ab}	18.98^{bcde}	20.32^{AB}	22.56^{bcde}	24.14^{ab}	21.34^{bcde}	22.68^{AB}
Ca-citrate	21.20^{abc}	22.00^{ab}	19.27^{bcde}	20.82^{A}	23.56^{abc}	24.30^{ab}	21.63^{bcde}	23.16^{A}
Control	18.50^{cde}	19.35^{bcde}	17.00^{e}	18.28^{C}	20.86^{cde}	21.71^{bcde}	19.30^{e}	20.64^{C}
Mean	20.21^{B}	21.32^{A}	18.51^{C}		22.57^{B}	23.68^{A}	20.87^{C}	

* Means followed by the same letters are not significantly differed according to LSD at 5% level.

** Fed. = 4200m^2

As for the somewhat superiority of K-citrate, results could be explained as this nutrient enhanced plant growth, total chlorophyll and carbohydrate accumulation. Carbohydrates is well-known to enhance pollen viability and consequently increasing fruit set Bishnu and Zeev (2004) came to similar conclusion.

Another confirmation was done by Hamid and Mohsen (2011) who noticed that K application significantly increased number of tomato fruits.

As for studied tomato hybrids, that of TH 99809 had the highest number of fruits / plant and average fruit weight (Table 9). GS-12 and NS × 9535 hybrids occupied the second and third rank.

Results could be interpreted on the base of the superiority of TH 99809 hybrid in growth characters and have high values of nutrients use efficiency, factors that may affect yielding potentiality. Similar results were obtained by Midan and Gabal (1986) on peppers, Rao and Chonkar (1981) and Gill *et al.* (1982) also on peppers. They attributed these variations to heredital factors.

As for the interaction between the two studied factors, TH 99809 hybrid produced high values of number of fruits and average fruit weight when plants received NPK-humates (Table 9).

Early and total yields

As it could be seen from such data, NPK-humates were of the highest records in early and total yields as compared to control or the other tested treatments (Table 9).

In addition, K-citrate showed somewhat superiority in this regard, as chelated micro-nutrients came with insignificant differences in the third rank. Results were insistently observed in both seasons.

Obtained results are in accordance with those of Hamid and Mohsen (2011) and Hasanein (2011) on tomato.

Further confirmation was done by Maryam (2012), who reported that humates increased plant yield via increasing root absorption of nutrients, plant photosynthesis and respiration and consequently improving growth, flowering and fruitting.

As for the tested hybrids, TH 99809 hybrid approved to be of the highest early and total yields in both seasons (Table 9). It was followed by GS-12 as NS × 9535 came at the last rank regarding yield parameters.

The differences among the tested hybrids in early and total yields were quite expected as these yield indices seems to be dependent on heredity. This suggestion was confirmed by the results of Cengiz and David (2002) working on tomato. The authors reported that the hybrids differences indicated an inherent differences.

The highest values of both yield parameters were obtained from TH 99809 hybrid as interacted with NPK-humates (Table 9). Besides, the lowest values being obtained in NS × 9535 hybrid receiving Ca-citrate.

REFERENCES

Abd El-Al, F.S., M.R. Shafeek, A.A. Ahmed and A.M. Shaheen (2005). Response of growth and yield of onion plants to potassium fertilizer and humic acid. J. Agric. Sci., Mansoura Univ., 30 (1): 441 – 452.

Abou El-Khair, E.E., I.A.S. Al-Esaily and N.M. El-Sarkassgy (2011). Physiological response of garlic plant grown in sandy soil to foliar spray with iron, zinc and manganese either individual or in mixture form. Minoufiya J. Agric. Res., 36 (2): 409 – 426.

A.O.A.C. (1990). Official Methods of Analysis of the Association of Official Agriculture Chemists, 15th ed. (1): 47-57.

Bishnu, P.C. and W. Zeev (2004). Effect of potassium magnesium chloride as source of potassium on growth, yield and quality of greenhouse tomato. Scientia Horticulturae, 99 : 279 – 288.

Bohme, M. and H. Thi-Lau (1997). Influence of mineral and organic treatments in the rhizosphere on the growth of tomato plants. Acta Horticulturae, 450: 161 – 168.

Cengiz, K. and H. David (2002). Response of tomato (*Lycopersicon esculentum* L.) cultivars to foliar application of zinc when grown in sand culture at low zinc. Scientia Horticulturae, 93: 53 – 64.

Chapman, H.D. and J.F. Pratt (1961). Methods of Analysis of Soil, Plants and Waters. University of Calif., Dev. Agric. Sci.

Chauduni, B.B. and R. De (1975). Effect of soil and foliar application of phosphorus on yield of tomato (*Lycopersicon esculentum* Mill.). Soil Science and Plant Nutrition, 21: 57-62.

Coltman, R.R. (1983). Intraspecific variation in tomato for dry matter accumulation under maintained and diffusion controlled phosphoras deficiency. Dissertation Abstr. International 3, 44 (3): 662 (C. F. Plant Breeding Abstr., 94 (2/3): 1892, 1984).

Costat Software (1985). User's Manual Version 3. Chort. Tusson, Arizona.

Dubois, M., A. Gilles, J.K. Hanelton, P.A. Robers and P.A. Smith (1956). A colorimetric method for determination of sugar and related substances. Annal. Chem., 28 : 250.

El-Morsy, A.H.A., Z.S. El-Shal and M.H. Sarg, Sawsan (2004). Effect of potassium application methods and some micronutrients on growth, yield and storability of garlic. J. Agric. Sci., Mansoura Univ. 29 (4): 2013 – 2023.

El-Sayed, S.F., M. Alphonse and E.M. Saad (2010). Effect of shading and calcium levels on growth and yield of some sweet pepper cultivars during summer season. Minufiya J. Agric. Res., 35 (4): 1521 – 1531.

English, J.E. and A.V. Barker (1987). Ion interactions in calcium-efficient and calcium-inefficient tomato lines. J. Plant Nutr., 10 : 857 - 869.

Gill, H.S., P.C. Thakur, B.M. Afawa and T.C. Thakur (1982). Diversity in sweet pepper. Indian J. Agric. Sci. 52(3): 159-163.

Giskin, M.L., A.T. Santos and J.D. Etcheves (1984). Can the foliar application of essential nutrients decrease fertilizer inputs? In: Proc VIIth Colloquium for the Optimalization of Plant Nutrition I, Montpellier Cedex, France.

Graham, R.D. (1984). Breeding for nutritional characteristics in cereals. In Advances in Plant Nutrition, 1: 57-102. Praeger, New York.

Haghighi, M., M. Kafi, P. Fang and L. Gui-Xiao (2010). Humic acid decreased hazardous of cadmium toxicity on lettuce (*Lactuca sativa* L.). Veg. Crops Res. Bull., 72: 49-61.

Hamid, R.R. and H. Mohsen (2011). Effects of foliar application of some macro and micro-nutrients on tomato plants in aquaponic and hydroponic systems. Scienta Horticulturae, 129: 396 – 402.

Hasanein, N.M. (2011). Effect of natural fertilizers, enciabein (slow release nitrogen fertilizer) and Bio-fertilizers on tomato production under plastic house conditions. Minufiya J. Agric. Res., 36 (6): 1687 – 1700.

Hebbar, S.S., B.K. Ramachandrappa, H.V. Nanjappa and M. Prabhakar (2004). Studies on NPK drip fertigation in field grown tomato (*Lycopersicon esculentum* Mill.). Europ. J. Agronomy, 21: 117 – 127.

Hernandez, M.S., R.E.M. Rodriguez and R.C. Diaz (2007). Mineral and trace element concentration in cultivars of tomatoes. Food Chemistry, 104: 489 – 499.

Inaki, A., P. Inmaculada, A. Jone, F. Marta, M.G. Jose and S. Manuel (2011). Growth and development of pepper are affected by humic substances derived from composted sludge. J. Plant Nutr. Soil Sci., 174: 916 – 924.

Khalil, M.A.I. (1990). Response of tomato hybrid plants (F_1) to foliar spray with some growth regulators under plastic houses condition. Zagazig J. Agric. Res., 17: 429 – 439.

Kleinkopf, G.E., D.T. Westermann and R.B. Dwelle (1981). Dry matter production and nitrogen utilization by six potato cultivars. Agron. J., 273: 799-802.

Komosa, A. (1990). Influence of some properties of chemical solutions and nutritional status of plant on efficiency of foliar fertilization of greenhouse tomato. Rocz. AR Poznafi. Research Dissertation, 210.

Loneragan, J.F. and C.J. Asher (1967). Response of plants to phosphate concentration in solution culture II- rate of phosphate absorption and its relation to growth. J. Soil Sci. 103: 311-318.

Lulakis, M. D. and Petsas, S. I. (1995). Effect of humic substances from vine-canes mature compost on tomato seedling growth. Bioresource Technology, 54: 179 – 182.

Maryam, H. (2012). The effect of humic and glutamic acids in nutrient solution on the N metabolism in lettuce. J. Sci. Food Agric., Published on line in Wiley online Library.

Midan, A. (1972). Efficiency of phosphate and manganese utilization in relation to the yield of snap bean. M.Sc. Thesis, Faculty of Agriculture, Ain Shams Univ., Egypt.

Midan, A., M.M. El-Sayed, S.R. El-Khateeb and M.Z. Abdel-Hak (1989). Some biochemical and pathological studies on potato cultivars in relation to chelates application. Minufiya J. Agric. Res., 10 (4): 2317 – 2346.

Midan, A. and M.R. Gabal (1986). Studies on three pepper cultivars as responded to five foliar fertilizers applications. Annals of Agric. Sci., Moshtohor, 24 (3): 1553-1569.

Midan, S.A. (2003). Studies on some factors affecting growth, yield and fruit quality of pepper. Ph D Sci. Thesis Fac. Agric. Minufiya Univ. Egypt.

Nelson, R.L. (2008). Aquaponic Food Production. Nelson and Pade Inc. Press, Montello, WI, USA, 218.

Norman, Q.A., L. Stephen, A.E. Clive and A. Rola (2003). Effects of humic acids derived from cattle, food and paper-waste vermicomposts on growth of greenhouse plants. Pedobiologia, 47: 741 – 744.

Pinton, R., S. Casco, S. Santi, F. Agnolon and Z. Varanini (1999). Water extractable humic substances enhance iron deficiency responses by Fe deficient cucumber plants. Plant and Soil, 210: 145 – 157.

Ramakumar, P.V., N. Sriramachandramurthy and M.M.K. Durgaprasad (1981). Genetic variability correlation and discriminant function in chili. Indian J. Agric. Sci., 51 (10): 823-828.

Rao, P.V. and V.S. Chonkar (1981). Correlation and path coefficient analysis in chili. Indian J. Agric. Sci., 51 (12): 857-860.

Riley, M.M., K.G. Adcock and M.D.A. Bolland (1993). A small increase in the concentration of phosphorus in the sawn seed increased the early growth of wheat. J. Plant Nutr., 16 (5): 851- 864.

Roods, F.M. and M.E. Blood Worth (1964). Area measurement of cotton leaf by dry weight method, Agron. J., 56 (5): 520-525.

Rosen, H. (1957). A modified ninhydrin colorimetric analysis for acid nitrogen. Arch. Biochem. Biophys, 67: 10-15.

Snedecor, G.W. and W.G. Cochran (1972). Statistical Methods. 6th ed. Iowa State Univ., Press, Iowa, U.S.A., 120 – 245.

Snell, F.D. and C.T. Snell (1953). Colorimetric method of analysis inducing some turbidimetric and rephelometric method. D. Van Nostrad Company Inc. Prencetion New Jerry, Toronto, New York, London, 3: 606.

Stevenson, F.J. (1994). Humus chemistry: Genesis, composition, reactions. New York: John Wiley and Sons, U.S.A.

Synsuke, K., E.M. Reda, A.E. Hany, R. Panigrah, K.M. Parvat, J. Ito, T.N. Nguyen, S. Hirofumi and F. Kounosuke (2011). Potassium deficiency affects water status and photosynthetic rate of the vegetative sink in greenhouse tomato prior to its effects on source activity. Plant Science, 180:368 – 374.

Top, C.F., C.A. Wason and E. Stockdal (2002). Utilizing the concept of nutrients as a currency within organic farming systems. In: Powell *et al.* (Eds.). Proc. of the COR Conf., 26 - 28 March, UK, pp: 157 – 160.

Witham, F.H., D.F. Blaydes and P.M. Devlin (1971). Experiments in plant physiology, pp. 55-58, Van Nosland Reinhold Co., New York.

Woolly, J.T., G.P. Hicks and R.H. Hageman (1960). Rapid determination of nitrate and nitrite in plant material. J. Agric. Food Chem., 8: 481-482.

استجابة بعض هجن الطماطم الحديثة للرش الورقى ببعض العناصر الكبرى والصغرى العضوية

سالى عبد الرازق ميدان

قسم البساتين – كلية الزراعة – جامعة المنوفية – شبين الكوم

أجريت تجربتان حقليتان خلال شتاء موسمى ٢٠١٠/٢٠١١، ٢٠١١/٢٠١٢ لدراسة تأثير بعض العناصر الكبرى والصغرى العضوية مثل هيومات (النيتروجين و الفوسفور و البوتاسيوم) والعناصر الصغرى المخلبية وسترات البوتاسيوم العضوية وسترات الكالسيوم العضوية على النمو، والمحتوى الكيماوى، والمحصول لثلاث من هجن الطماطم الحديثة وهى GS-12 و TH 99806 وNS X 9535 ، أدت جميع المعاملات تحت الدراسة إلى زيادة معنوية فى طول النبات وعدد الأوراق وعدد الأفرع ومساحة اوراق النبات والوزن الغض والجاف لكلٍ من الأوراق والسيقان والجذور مقارنة بالنباتات غير المعاملة (الكنترول)، كما ازداد معنوياً محتوى أوراق نباتات الطماطم من كل من كلوروفيل (أ ، ب) والكاروتين والنيتروجين والفوسفور والبوتاسيوم ومعدل الاستفادة منهم بجميع المعاملات تحت الدراسة، وكانت أفضل المعاملات للحصول على أعلى محصول مبكر و محصول كلى ومكوناته وأفضل جودة للثمار متمثلة فى محتوى عصير الثمار من فيتامين ج ومحتوى الثمار من المواد الصلبة الكلية هى رش نباتات الطماطم بهيومات (النيتروجين والفوسفور والبوتاسيوم)، بينما أدى رش نباتات الطماطم بالعناصر الصغرى العضوية وسترات الكالسيوم وسترات البوتاسيوم إلى نقص واضح فى تراكم النترات فى ثمار الطماطم.