J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 3 (8): 815 - 827, 2012

EFFECT Of NITROGEN, SODIUM, CALCIUM AND THEIR INTERACTION ON YIELD AND COMPOSITION OF TOMATO FRUIT.

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ABSTRACT

Sandy culture experiment was conducted at Fac. of Agric., Mansoura University during the two summer successive seasons of 2010 and 2011 aimed to investigate the effect of N (30.0 and 150.0 ppm) , Na (0.0 and 4.0 meq / l) and Ca (0.0, 5.0, 10.0 and 20.0 meq / l) in nutrient solution and their interaction on tomato fruit composition. Combination between the studied factors levels comprise sixteen treatments which were arranged in a split split block design with 3 replicates .

The obtained results can be summarized in the following :-

Significant increase in tomato fruit numbers amounted by 19.72 % in the first season and 19.49 for the second one, where the total yield increases were 18.89 and 18.64 for first and second season, respectively . So fruit weight average significantly varied due to N level increase from 30.0 ppm to 150.0 ppm (29.12 and 15.41 % increase in the first and second season, respectively) .

Sodium application (4.0 meq /l)reduced total yield of tomato fruit by 5.16 % in the first season and a slight increase than that was found in the second one (5.5 % reduction).

N content of tomato fruit was increased from 2.53 to 3.09 % (22.13 % increase) in the first season and from 2.70 to 3.19 % (18.15 % increase) in the second season due to N level increase in nutrient solution from 30. to 150.0 ppm.

sodium level of 4.0 meq / l in nutrient solution significantly reduced N, P, and K content of tomato fruits.

Potassium content of tomato fruits was decresed as nutrient solution Ca increase up to the highest level used (20.0 meq /l) in both season. 20.0 meq / l Ca decreased potassium content of tomato fruit by 5.56 and 4.79 %, compared with control, in the first and second season, respectively .

Neither statistically effect nor constant trend was found on total Ca resulting from increasing the nitrogen level from 30.0 to 150.0 meq /l in both seasons.

NaCl -Ca took the opposite trend of total calcium, where NaCl -Ca of tomato fruits was increased (5.07 % increase), in the first season and decreased (4.72% decrease) in the second one due to the same increase in N level (from 30.0 to 150.0 meq /l).

HAC-Ca, HCl-Ca and Res-Ca showed a constant trend against N level increase in both seasons. 4.0 meq /l treatment significantly increased all Ca forms in tomato fruit in both seasons, compared with that of no sodium addition .

10.0 meq / l treatment achieved the highest values of total Ca in both season (1726.24 and 1768.78 ppm for the first and second season , respectively).

A concomitant increase in Eth-Ca with increasing Ca level in nutrient solution up to 10.0 meq / l then slightly decreased with 20.0 meq / l treatment in both seasons.

A strongly increasing trend in NaCl – Ca by increasing Ca level in nutrient solution from 0.0 Ca addition to 5.0 meq /l in nutrient solution (from 883.6 to 1253.48 and from 926.74 to 1222.90 , in the first and second season, respectively) . Lower decreasing rate (from 1396.25 to 1295.65 and from 1330.26 to 1256.98 ppm , in the first and second season, respectively) was found regarding to NaCl – Ca form with increasing Ca level from 10.0 to 20.0 meq Ca /l .

In both seasons Ca oxalate was significantly increased with increasing Ca level from 0.0 to 10.0 meq /l in nutrient solution, these increases appreciated by 276.49 and 275.33 % in the first and second season , respectively . A significant decrease in tomato fruit calcium oxalate due to increasing Ca in nutrient solution from 10.0 to 20.0 meq /l (26.62% and 25.93% increase in the first and second season respectively) .

Keywords: Nitrogen, Sodium, Calcium , Nutrient solution ,Sandy culture , tomato fruits.

INTRODUCTION

Tomato *(Lycopersicon esculentum Mill.)* is a major component of daily meals in many countries and constitutes an excellent source of health-promoting compounds due to the balanced mixture of minerals and antioxidants.

In Egypt, farmers consume large amounts of mineral fertilizers to increase the yield without any care of the adverse effects on chemical constituent of grown crops.

calcium, an essential macronutrient, plays a decisive role in the maintenance of cell membrane integrity and membrane permeability; enhancing pollen germination and growth; activating a number of enzymes for cell mitosis, division, and elongation; possibly detoxifying the presence of heavy metals in tissue; affecting fruit quality, and health of conductive tissue, (Jones,1999). Calcium is involved in numerous cellular functions that are regulated in plant cells by changes in cytosolic Ca^{2+} concentrations, such as ionic balance, gene expression, and carbohydrate metabolism Bush (1995).

Calcium in tomato fruit is very important, It is a significant enhancer of the commercial value of tomato. Ca affect mechanical properties, where calcium application resulted in firmness increase (Rajabipour ,1995).

Calcium in tomato fruit exists as a number of ca compounds. These calcium compounds of fraction were mainly regarded as Ca $(NO_3)_2$ and $CaCl_2$ (ethanol – Ca), soluble organic calcium such as Amino acid Calcium salts(H_2 O- Ca), Calcium pectate (NaCl – Ca), Calcium phosphate and Calcium carbonate (HAc-Ca) and Calcium oxalate (Hcl – Ca). The final residue was dry – ashed and dissolved by 6 mol/ L Hcl , the Ca in the residue was considered as the indissolved Ca such as calcium silicate (Res-Ca).

This study aimed to assess the external N, Na, Ca levels and their interaction on N, P, K and Ca forms and content of tomato fruit .

MATERIALS AND METHODS

Sandy culture experiment was conducted at Fac. of Agric., Mansoura University during summer seasons of 2010 and 2011. Sandy textured soil(

85.1 % Sand , 8.3 % Silt and 6.6%Clay) was collected from the surface layer (0-20 cm); of a special farm near Qulabsho village, Dakahlia Governorate. Soil was washed with concentrated HCl three times (three days intervals) and then washed with tap water up to remove the residual effect of chloride(10 times, with a large quantities of water). Soil reaction of washed soil paste was 7.4 and the electrical conductivity of that soil paste extract was 0.5 $dS.m^{-1}$.

A split split block design was used, where two nitrogen levels (30 and 150 ppm in nutrient solution) were allocated in main plots, Two sodium levels (0.0 and 16 meq /l in nutrient solution) were allocated in sub plot and four Ca levels(0.0,5.0,10.0,20.0meq/ l in nutrient solution) were in sub sub plot . Combination between the studied factors levels comprise Sixteen treatments , each one was replicated three times . Plastic pots , 20 cm in diameter and 30cm height were used. Each pot was filled with 10.400 kg of air dried soil (10 kg of dry soil basis).

On 4 march of 2010 and 2011, three seedlings 35 days old of tomato plants (lycopersion esculentum Mill) Varity-Super strain B. were transplanted in each pot . Nutrient solution directly after transplanting was added (fifth strength of the normal used nutrient solution) . One week later, seedling were thinned to the most suitable uniform one per pot.

Appropriate Hoagland solutions (5 ml of potassium sulphat (0.5M), 5 ml of potassium dihydrogen ortho-phosphate (1M), 2.5 ml of magnesium sulphat (1M), 2.5 ml of micro nutrient solution (2.86gm boric acid, 0.264gm manganese sulphate, 0.04gm molybedic acid, 0.08gm cupper sulphate and o.22gm zink sulphate /l.) and 10 ml Fe EDDHA (1.6 gm of Fe EDDHA ; 6.0 % Fe / l) solution / liter was prepared) containing different N, Na and Ca levels were prepared and used for this experiment . nutrient solution and tap water were alternatively added, three days interval, where tap water was added to compensate evapotranspiration and the nutrient solution was added with a large quantities (two fold of saturated soil demand).

Nineteen days after transplanting, tomato fruits were collected and weighted for each pot. Representative samples of tomato fruits were taken randomly from each pot yield.

0.4 gm of tomato fruit samples (oven dry basis) were digested in a mixture of HClO4 and H2SO4 according to the procedure of Chapman and Pratt (1961).

Nitrogen, phosphorus, potassium, sodium and magnesium in plant digestion product were determined according to Jackson,(1967). The electrical conductivity was measured in soil paste extract and Soil reaction (pH) value was measured in soil water suspensions as described by Jackson (1967). The analytical procedure of Ca fractionation was done according to Ohat *et al*;1970. Calcium concentration in the extracts was determined by atomic absorption spectrophotometer . Three replications per treatment were included.

The statistical analysis of the collected data was done according to the method described by (Gomez and Gomez, 1984) using LSD to compare the means of treatment values.

RESULTS AND DISCUSSION

Data plotted in Table 1 illustrate the effect of nitrogen, Sodium , Calcium levels and their interaction on tomato fruit numbers, total yield and the average of fruit weight.

Data reveal that significantly increase in tomato fruit numbers as well as total yield and fruit weight average in both seasons due to N level increase from 30.0 ppm to 150.0 ppm were found . Fruit number increase amounted by 19.72 % in the first season and 19.49 for the second one, where the total yield increases were 18.89 and 18.64% for first and second season, respectively . So fruit weight average significantly varied due to N level increase from 30.0 ppm to 150.0 ppm (29.12 and 15.41 % increase in the first and second season, respectively) . These results are in contradictory trend with that of Olasantan (1991). Who found that fruit yield of tomato plant was reduced at higher N application rates.

Data of that Table pointed out that the studied level of sodium did not significantly affect tomato fruit number , where it significantly affect each of total yield and fruit weight average . Sodium application (4.0 meq /l)reduced total yield of tomato fruit by 5.16 % in the first season and a slight increase than that was found in the second one (5.5 % reduction). Fruit weight average reduction was higher in the first season than that of the second one (13.82 and 5.2 % decrease in the first and second season, respectively). These results are in agreement with that of Tantawy *et al.,* (2009) who stated that yield responded negatively as the NaCl level increased.

Concerning to calcium levels effect on fruit number, total yield and fruit weight average , data plotted in Table 1 reveal that increasing calcium levels up to 20.0 meq /l didn't significantly affect fruit number in both seasons, where the fruit number in the first season was higher than that of the second season. On the other hand, Calcium addition tended to decrease total fruit yield as well as the fruit weight average. Rising calcium level from 0.0 to 20.0 meq /l significantly decreased total yield of tomato fruit and the higher decrease was noticed in the second season (3.67 and 4.16 % decrease in the first and second season, respectively). These results may be complete the results of Nzanza (2006). Who stated that only a Ca :Mg ratio of less than one can cause a significant reduction in yield .

Fruit weight average was reduced significantly due to calcium addition increase from 0.0 to 20.0 meq / l , where it was reduced from 35.83 to 31.17 (13.01 % decrease) in the first season and from 25.08 to 24.08 (3.99 % decrease) in the second season .

Data of Table 1 illustrate that No significant interactive effect was found between the studied factors level concerning to tomato fruit number both seasons. On the other hand, significant interaction effects were found regarding to total yield and fruit weight average . It is worthy to identify that the treatment of 150.0 ppm N – 0.0 sodium – 0.0 Calcium recorded the the highest value of both total yield (238.33 and 218.33 gm) and fruit weight average (39.67 and 27.33 gm) in both seasons .

Table(1): Effect of N, Na and Ca application levels on number of fruit, total yield and fruit weight average of tomato fruits.

Parameters. Treatments			No. of fruit		total yield (gm)		fruit weight average (gm)	
			1st	2nd	1st	2nd	1st	2nd
Main								
30 ppm N			9.33	7.08	187.08	167.17	28.88	22.46
150 ppm N			11.17	8.46	222.42	198.33	37.29	25.92
LSD for 5%			**1.17**	**0.82**	**1.71**	**3.68**	**0.73**	**1.25**
0.0 meq Na / L			10.54	7.96	210.17	187.92	35.54	24.83
4.0 meq Na / L			9.96	7.58	199.33	177.58	30.63	23.54
LSD for 5%			**N.S**	**N.S**	**1.70**	**2.23**	**0.77**	**0.58**
0.0 meq Ca / L			10.67	7.50	211.42	190.17	35.83	25.08
5.0 meq Ca / L			9.92	7.67	199.25	177.00	33.67	23.50
10.0 meq Ca / L			10.33	7.83	204.67	181.58	31.68	24.08
20.0 meq Ca / L			10.08	8.08	203.67	182.25	31.17	24.08
LSD for 5%			**N.S**	**N.S**	**1.13**	**2.48**	**0.53**	**0.49**
30 ppm N	0.0 meq Na / L	0.0 meq Ca / L	10.00	7.67	194.33	173.67	34.00	24.00
		5.0 meq Ca /L	9.00	6.67	180.67	161.33	31.00	21.33
		10 meq Ca / L	10.00	7.33	198.67	177.67	34.00	23.67
		20 meq Ca / L	9.00	8.00	186.33	166.67	32.00	22.33
	4.0 meq Na / L	0.0 meq Ca / L	9.33	5.33	190.67	170.33	31.67	22.67
		5.0 meq Ca /L	8.33	6.67	175.00	156.00	29.33	21.00
		10 meq Ca / L	9.33	8.00	181.00	164.33	19.39	22.33
		20 meq Ca / L	9.67	7.00	190.00	167.33	19.66	22.33
150ppm N	0.0 meq Na / L	0.0 meq Ca / L	12.00	8.67	238.33	218.33	39.67	27.33
		5.0 meq Ca / L	11.67	8.33	224.67	198.33	37.33	26.33
		10 meq Ca / L	11.67	8.67	231.67	204.67	38.67	27.33
		20 meq Ca / L	11.00	8.33	226.67	202.67	37.67	26.33
	4.0 meq Na / L	0.0 meq Ca / L	11.33	8.33	222.33	198.33	38.00	26.33
		5.0 meq Ca / L	10.67	9.00	216.67	192.33	37.00	25.33
		10 meq Ca / L	10.33	7.33	207.33	179.67	34.67	23.00
		20 meq Ca / L	10.67	9.00	211.67	192.33	35.33	25.33
LSD for 5%			**N.S**	**N.S**	**2.26**	**4.98**	**1.08**	**0.98**

The effects of the studied levels of N , Na , Ca and their interaction on N, P and K content of tomato fruit are presented in Table 2. Data declare that N content of tomato fruit was increased from 2.53 to 3.09 % (22.13 % increase) in the first season and from 2.70 to 3.19 % (18.15 % increase) in the second season due to N level increase in nutrient solution from 30. to 150.0 ppm . data also reveal that these increases are significant .

A lower increase in P or K content of tomato fruit compared with that of N content due to the same increase in N level in nutrient solution (from 30.0 to 150.0 ppm),where, 6.38 and 4.38 increase in P content and 6.27 and 5.08 % increase in K content of tomato fruit for the first and second season , respectively .

Regarding to sodium effect on N, P, and K content of tomato fruit data of Table 2 stated that sodium level of 4.0 meq / l in nutrient solution significantly reduced N, P, and K content of tomato fruits. In the first season the reduction percentages were 7.53, 6.22 and 7.10 % for N, P, and K , respectively , Corresponding values in the second season were 5.08, 4.97 and 6.59 % . These results are in agreement with that of Flores *et al.,* (2001). They found that sodium chloride inhibits the uptake and transport of potassium and phosphorus, where Na cation competes mainly with K due to their similar valance structure, and interferes in normal cellular processes(Fonseca *et al.,* 2007).

Table 2 illustrate Ca levels effects on N, P, and K content of tomato fruits ,where Little decrease in nitrogen content of tomato fruit as affected by Ca level in nutrient solution was found in both seasons. Nitrogen content of tomato fruit ranging between 2.94 to 2.73 % in the first season and between 3.05 to 2.95 % in the second season. Calcium level effect on N content of tomato fruit is not significant . These results are in acceptable trend with that of Yokafi *et al*., (2008). They stated that N concentrations was decreased with increasing $CaCl_2$ salt concentrations.

Table(2): Effect of N, Na and Ca application levels on N,P and K contents in tomato fruits.

Char. / Treat.			N% 1st	N% 2nd	P% 1st	P% 2nd	K% 1st	K% 2nd
30 ppm N			2.53	2.70	0.392	0.391	3.03	3.15
150 ppm N			3.09	3.19	0.417	0.408	3.22	3.31
LSD for 5%			**0.35**	**0.41**	**0.004**	**0.003**	**0.01**	**0.06**
0.0 meq Na / L			2.92	3.02	0.418	0.410	3.24	3.34
4.0 meq Na / L			2.70	2.87	0.391	0.390	3.01	3.12
LSD for 5%			**0.18**	**0.15**	**0.003**	**0.001**	**0.02**	**0.06**
0.0 meq Ca / L			2.94	3.05	0.419	0.409	3.24	3.34
5.0 meq Ca / L			2.76	2.85	0.401	0.394	3.08	3.18
10.0 meq Ca / L			2.80	2.93	0.403	0.400	3.11	3.23
20.0 meq Ca / L			2.73	2.95	0.395	0.396	3.06	3.18
LSD for 5%			**N.S**	**N.S**	**0.003**	**0.002**	**0.02**	**0.04**
30 ppm N	0.0 meq Na / L	0.0 meq Ca / L	2.71	2.80	0.413	0.404	3.21	3.31
		5 meq Ca / L	2.51	2.60	0.391	0.383	2.98	3.07
		10 meq Ca /L	2.76	2.87	0.418	0.411	3.27	3.38
		20 meq Ca / L	2.59	2.69	0.399	0.391	3.06	3.15
	4.0 meq Na / L	0.0 meq Ca /L	2.65	2.75	0.407	0.398	3.16	3.25
		5 meq Ca / L	2.43	2.50	0.385	0.377	2.94	3.03
		10 meq Ca / L	2.33	2.65	0.370	0.379	2.83	3.00
		20 meq Ca / L	2.25	2.70	0.353	0.382	2.79	3.02
150 ppm N	0.0 meq Na / L	0.0 meq Ca /L	3.31	3.44	0.438	0.429	3.41	3.51
		5 meq Ca / L	3.09	3.20	0.421	0.415	3.28	3.40
		10 meq Ca /L	3.22	3.30	0.433	0.424	3.37	3.47
		20 meq Ca / L	3.15	3.27	0.428	0.419	3.34	3.44
	4.0 meq Na / L	0.0 meq Ca /L	3.09	3.20	0.417	0.406	3.19	3.27
		5 meq Ca / L	3.01	3.10	0.408	0.399	3.12	3.21
		10 meq Ca / L	2.88	2.90	0.392	0.384	2.98	3.07
		20 meq Ca /L	2.94	3.13	0.399	0.391	3.03	3.12
LSD for 5%			**N.S**	**N.S**	**0.005**	**0.004**	**0.04**	**N.S**

Table 2 reveal Ca levels in nutrient solution effects on P content of tomato fruit, where P content of tomato fruit negatively responded to Ca level increment in nutrient solution. In the first season Phosphorus content of tomato fruit was decreased by 4.30 % with the first increase in Ca content of nutrient solution (5.0 meq/l) in the first season, while it was decreased by 3.67% in the second season . Similar trend was illustrated by Bozkurt *et al*., (2008). They reported that Ca application decreased P concentrations of tomato fruit grown in a greenhouse .

K content of tomato fruits as affected by Ca levels are shown in Table 2. Potassium content of tomato fruits was decreased as nutrient solution Ca increase up to the highest level used (20.0 meq /l) in both season. 20.0 meq / l Ca decreased potassium content of tomato fruit by 5.56 and 4.79 %, compared with control, in the first and second season, respectively . These result support Carvajal *et al.,* (1999) result . They outlined that, potassium level of tomato fruit was decrease with increasing Ca concentration (0.5 to 10 mmol / l)in the nutrient solution.

Data of Table 2 illustrate that No significant interactive effect was found between the studied factors level concerning to N content of tomato fruit in both seasons. On the other hand significant interaction effects were found regarding to P content and K content . It is worthy to identify that the treatment of 150.0 ppm N – 0.0 sodium – 0.0 Calcium recorded the the highest values of N (3.31 and 3.44 %), P (0.438 and 0.429 %), and K (3.41 and 3.51%) in both seasons .

Data of Tables 3 and 4 show the N , Na , Ca and their interaction effects on Ca forms of tomato fruits . Data of Tables reveal that neither statistically effect nor constant trend was shown on total Ca resulting from increasing the nitrogen level from 30.0 to 150.0 ppm in both seasons, where total calcium of tomato fruits was decreased (6.61 decrease), in the first season and increased (5.85 increase) in the second one due to the same increase in N level. These results are in the same trend of Elder *et al*., (1998) results. They studied the effect of different calcium (Ca) doses (0.2, 2.5, 5.0, 10.0, 15.0, and 20.0 mmol L /1) in the nutrient solution used to cultivate tomato plants on the nutrient and carotene levels of tomato *(Lycopersicon esculentum* Mill. Cv. *Jumbo)* fruit. They stated that calcium level in the fruit was increased with increasing Ca concentrations in the nutrient solution.

Eth-Ca was decreased due to N-level increase in both season (12.83 and 7.97 % decrease in the first and second season, respectively), meanwhile the first season decrease is significant and the second seson decrease is not significant .

H_2O -Ca took the same trend of Eth-Ca, where it was also decreased due to N-level increase in both season, meanwhile the first season decrease is significant and the second season decrease is not significant . Decreasing rate of that trait is higher than that of Eth-Ca, where H_2O-Ca form was decreased by 18.56 % in the first season and by 10.42 % in the second season.

NaCl -Ca took the opposite trend of total calcium, where NaCl -Ca of tomato fruits was increased (5.07 %), in the first season and decreased (4.72%) in the second one due to the same increase in N level (from 30.0 to 150.0 ppm). Data of Tables 3 and 4 reveal that either increase or decrease statistically characterize by significant.

HAC-Ca showed a constant trend against N level increase in both season, where it was decreased from 86.06 to 75.04 ppm (12.81 %) in the first season and decreased from 83.22 to 71.89 ppm(13.61%) in the second season.

HCl-Ca showed a constant trend against N level increase in both season, where it was increased by 3.65 and 3.53 % in the first and second season, respectively.

Res-Ca was significantly decreased with increasing the N level from 30.0 to 150.0 ppm in nutrient solution but the reduction in that trait was very higher in the first season (26.76 %) than that of the second season (3.22).

Data in Tables 3 and 4 show the Na effect on Ca forms of tomato fruits. It is worthy to reveal that 4.0 meq /l treatment significantly increased all Ca forms in tomato fruit in both season, compared with that of no sodium addition .

Table(3): Effect of N, Na and Ca application levels on Ca forms of tomato fruits (ppm) in the frist season.

Char. Treat.			T.Ca	Eth-Ca	H_2O-Ca	NaCl-Ca	HAC-Ca	HCl-Ca	Res-Ca
30 ppm N			1518.05	69.28	43.22	1116.51	86.06	55.55	22.31
150 ppm N			1417.64	60.39	35.2	1173.1	75.04	57.58	16.34
LSD for 5%			**NS**	**0.45**	**0.18**	**10.38**	**0.54**	**NS**	**0.34**
0.0 meq Na / L			1269.21	50.7	30.51	1071.65	65.64	36.48	14.24
4.0 meq Na / L			1666.49	78.96	47.91	1342.9	95.46	76.65	24.41
LSD for 5%			**208.41**	**0.14**	**1.1**	**56.97**	**2.3**	**1.66**	**0.21**
0.0 meq Ca / L			1031.71	39.38	25.13	883.6	50.74	22..93	9.70
5.0 meq Ca / L			1515.83	65.43	40.23	1253.48	84.90	53.65	18.90
10.0 meq Ca / L			1726.24	80.23	46.40	1396.25	92.75	86.33	24.28
20.0 meq Ca / L			1597.6	75.05	45.08	1295.65	93.75	63.35	24.43
LSD for 5%			**237.26**	**2.3**	**1.2**	**46.75**	**1.8**	**1.87**	**0.13**
30 ppm N	0.0 meq Na / L	0.0 meq Ca /L	883.85	34.60	17.90	764.90	42.75	16.80	6.90
		5 meq Ca / L	1632.05	72.30	42.30	1348.20	90.35	58.20	20.70
		10 meq Ca /L	1683.75	75.80	48.15	1388.30	91.30	57.30	22.90
		20 meq Ca /L	1597.4	71.20	43.50	1311.50	89.40	60.90	20.90
	4.0 meq Na / L	0.0 meq Ca /L	1253	50.40	42.70	1046.30	64.70	33.10	14.80
		5 meq Ca / L	1652.08	75.90	45.00	1347.00	95.18	66.40	22.60
		10 meq Ca /L	1698.4	81.60	50.30	1359.50	103.10	72.40	31.50
		20 meq Ca /L	1743.9	92.40	55.90	1366.40	111.70	79.30	38.20
150 ppm N	0.0 meq Na / L	0.0 meq Ca /L	764.2	24.30	12.80	677.30	31.90	12.70	5.20
		5 meq Ca / L	1254.2	42.80	33.90	1057.90	68.70	37.20	13.70
		10 meq Ca /L	1166	39.90	21.30	1016.70	51.80	22.90	13.40
		20 meq Ca /L	1172.2	44.70	24.20	1008.40	58.90	25.80	10.20
	4.0 meq Na / L	0.0 meq Ca /L	1225.8	48.20	27.10	1045.90	63.60	29.10	11.90
		5 meq Ca / L	1525	67.70	39.70	1260.80	85.40	52.80	18.60
		10 meq Ca /L	2356.8	123.60	65.90	1820.50	124.80	192.70	29.30
		20 meq Ca /L	1876.9	91.90	56.70	1497.30	115.20	87.40	28.40
LSD for 5%			**274.52**	**4.47**	**2.42**	**73.50**	**1.35**	**3.75**	**0.27**

Total Ca was increased from 1269.21 to 1666.49 (31.30 %) and from 1562.39 to 1653.73 (15.36%) in the first and second season respectively . Eth-Ca and H_2O-Ca were increased with similar rate, approximately (55.73 and 53.63 %for Eth –Ca in the first and second season, respectively and 57.03 and 53.66 %for H_2O –Ca in the first and second season, respectively). In spite of the greatest amount of NaCl – Ca form the increment percentage was the lower (25.31 and 18.68 %)in both seasons. HAC – Ca was increased from 65.64 to 95.46 and from 64.11 to 91.00 in the first and second season, respectively. The highest increase was found in HCl -Ca form (110.12 and 112.95% for first and second season, respectively) and Res –Ca form (71.42 and 78.80% for first and second season, respectively). From the data 4.0 meq Na /l of nutrient solution seems to be enough to enhance divalent cation absorption and not enough to compete with other cations. These results confirm the results of Chookhampaeng (2011). Who found that the low (50 mM NaCl) level of salinity treatment had no deleterious effects on vegetative growth parameters.

Table(4): Effect of N, Na and Ca application levels on Ca forms of tomato fruits (ppm) in the second season.

Char. Treat.			T.Ca	Eth-Ca	H_2O-Ca	NaCl-Ca	HAC-Ca	HCl-Ca	Res-Ca
30 ppm N			1562.39	71.41	44.90	1212.80	83.22	58.40	22.91
150 ppm N			1653.73	63.70	40.30	1155.52	71.89	60.46	17.59
LSD for 5%			**NS**	**NS**	**NS**	**14.95**	**1.84**	**NS**	**0.63**
0.0 meq Na / L			1401.47	53.27	33.64	1082.99	64.11	37.98	14.53
4.0meq Na / L			1616.72	81.84	51.69	1285.34	91.oo	80.88	25.98
LSD for 5%			**176.05**	**2.79**	**3.88**	**65.15**	**3.09**	**1.09**	**1.77**
0.0 meq Ca / L			1074.54	40.50	25.6	926.74	49.23	24.08	8.65
5.0 meq Ca / L			1628.85	69.17	42.3	1222.9	82.33	56.33	18.33
10.0 meq Ca / L			1768.78	85.68	52.15	1330.26	89.00	90.38	28.9
20.0 meq Ca / L			1564.23	74.86	50.65	1256.98	89.66	66.94	25.13
LSD for 5%			**84.22**	**4.14**	**3.93**	**87.50**	**1.19**	**1.53**	**1.15**
30 ppm N	0.0 meq Na / L	0.0 meq Ca / L	980.6	35.60	17.70	861.50	41.50	17.60	6.70
		5.0 meq Ca /L	2117.9	74.50	41.90	1282.80	87.60	61.10	20.10
		10 meq Ca / L	1732.13	76.30	50.10	1432.93	92.30	57.70	22.80
		20 meq Ca / L	1567.97	73.30	43.10	1280.70	86.67	63.90	20.30
	4.0 meq Na / L	0.0 meq Ca / L	1291.60	51.90	40.20	1090.50	62.80	34.80	11.40
		5 meq Ca / L	1582.7	78.10	44.50	1276.20	92.30	69.70	21.90
		10 meq Ca / L	1607.2	86.20	52.50	1254.40	99.40	77.50	37.20
		20 meq Ca /L	1619	95.40	69.20	1223.40	103.20	84.90	42.90
150 ppm N	0.0 meq Na / L	0.0 meq Ca / L	730.12	24.92	17.70	638.30	30.90	13.30	5.00
		5 meq Ca /L	1293.90	54.40	43.50	1077.00	66.60	39.10	13.30
		10 meq Ca / L	1541.40	41.10	31.10	1007.00	50.20	24.00	18.10
		20 meq Ca / L	1247.84	46.04	24.00	1083.67	57.10	27.13	9.90
	4.0 meq Na / L	0.0 meq Ca / L	1295.87	49.60	26.80	1115.67	61.70	30.60	11.50
		5 meq Ca / L	1520.90	69.70	39.30	1255.70	82.80	55.40	18.00
		10 meq Ca / L	2194.40	139.10	74.70	1626.70	114.10	202.30	37.50
		20 meq Ca / L	1822.09	84.70	66.30	1440.13	111.70	91.83	27.43
LSD for 5%			**168.45**	**8.28**	**5.86**	**112.56**	**2.38**	**3.06**	**2.29**

Regarding to Ca levels effect on total Ca, Data of Tables 3 and 4 outlined that 10.0 meq / l treatment achieved the highest values of total Ca in both season (1726.24 and 1768.78 ppm for the first and second season , respectively). Increasing Ca level above 10.0 meq /l significantly decreased total– Ca in both season, compared with that of 10.0 meq /l treatment. 10.0 meq/l treatment increased total calcium by 67.32% in the first season and by 64.61 % in the second season , compared with no Calcium addition in nutrient solution.

Regarding to Ca levels effect on Eth-Ca, Data of Tables3 and 4 outlined that a concomitant increase in Eth-Ca with increasing Ca level in nutrient solution up to 10.0 meq / l then slightly decreased with 20.0 meq / l treatment in both seasons.

In spite of drastically increase in H_2O – Ca form by adding 5.0 meq / l than that of control (60.09 and 65.23 % increase in the first and second season) , non Significant decrease in that trait was noticed by adding 20.0 meq / l comparing to 10.0 meq / l treatment . This trend may be due to the effect of high salt concentrations which increase the membrane permeability of plant roots, (Kaya *et al*., 2002).

NaCl – Ca in tomato fruits refer to Ca in pectate form which caused fruit hardness. As it is shown in Table 3 and 4 , NaCl – Ca in tomato fruits have a strongly increasing trend by increasing Ca level in nutrient solution from 0.0 Ca addition to 5.0 meq /l in nutrient solution (from 883.6 to 1253.48 and from 926.74 to 1222.90 , in the first and second season, respectively) . Lower increasing rate(from 1253.48 to 1396.25 and from 1222.90 to 1330.26 ppm , in the first and second season, respectively) was found in both seasons regarding to NaCl – Ca form with increasing Ca level from 5.0 to 10.0 meq Ca /l . Similar results were obtained by Dong *et al.,* (2004) and Bozkurt *et al*., (2008) . They outlined that Ca pectate in tomato fruit significantly increased with increasing Ca concentration in the nutrient solution and foliar application. Lower decreasing rate (from 1396.25 to 1295.65 and from 1330.26 to 1256.98 ppm , in the first and second season, respectively) was found regarding to NaCl – Ca form with increasing Ca level from 10.0 to 20.0 meq Ca /l . These results confirmed that of Hao and Papadopoulos (2003). They stated that 7.5 mM Ca in nutrient solution allow for higher total yields, higher marketable fruit yields, and higher percentages of marketable fruit compared to low Ca concentrations (3.5 mM) for maximum plant growth.

HAC-Ca {Calcium phosphate and Calcium carbonate} content of tomato fruits as affected by Ca level supply are shown in Tables 3 and 4 . HAc-Ca in tomato fruits have a strongly increasing trend (67.32 and 67.24 % increase) by increasing Ca level in nutrient solution from 0.0 Ca addition to 5.0.0 meq /l. Approximately plateau (very little increase, from 92.75 to 93.75 and from 89.00 to 89.66 ppm, in the first and second season, respectively) trend was found in HAc-Ca content of tomato fruits by increasing Ca in nutrient solution from 10.0 meq / l up to the highest level used (20.0 meq / l) . These results are in agreement with that of . Peyvast *et al.,* (2009). They stated that tomato crops fertilized with 6 mmol / L calcium nitrate and 4 mmolL-1 potassium phosphate have a greater quality.

Tomato fruit calcium oxalate (HCl – Ca) as affected by Ca levels was shown in Tables 3 and 4 . In both seasons Ca oxalate was significantly increased with increasing Ca level from 0.0 to 10.0 meq /l in nutrient solution, these increases appreciated by 276.49 and 275.33 % in the first and second season , respectively . A significant decrease in tomato fruit calcium oxalate due to increasing Ca in nutrient solution from 10.0 to 20.0 meq /l (26.62% and 25.93% increase in the first and second season respectively) . Higher increasing rate was found in HCl – Ca form in tomato fruit due to calcium addition than that of any other form .

The later form of tomato fruit calcium consider as indissolved Ca which mainly present as calcium silicate . calcium silicate of tomato fruit as influenced by Ca levels of nutrient solution are shown in Tables 3 and 4 . Tomato fruit calcium silicate in both season took the same manner. It was increased from 9.70 to 18.90 ppm and from 8.65 to 18.33 ppm in the first and second seasons with increasing the added level of calcium from 0.0 to 5.0 meq/l . Calcium silicate of tomato fruit treated with 10.0 meq Ca /l did not significantly differ than that of treated with 20.0 meq Ca/l in the first season (24.28 and 24.43 ppm for 10.0 and 20.0 meq Ca/l treatments, respectively).

Data in Tables 3 and 4 reveal Nitrogen levels – Sodium levels - Ca levels interaction on Ca forms of tomato fruit , where a significant interaction effects were found between the studied factors levels regarding to all Calcium form studied in both seasons. The treatment of 150.0ppm N – 4.0 meq Na /l – 10.0 meq Ca / l have the highest mean values of total calcium (2356.8 and 2194.40), Eth –Ca (123.60 and 139.10), H2O – Ca (65.90 and 74.70) , NaCl – Ca (1820.50 and 1626.70),HAC- Ca (124.80 and 114.10) and HCl – Ca (192.70 and 202.30) in both seasons. The treatment of 150.0ppm N – 0.0 meq Na /l – 0.0 meq Ca / l have the lowest mean values of HCl – Ca (12.70 and 13.30) and Res – Ca (5.20 and 5.0 ppm) in both seasons.

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تــأثير النيتــروجين والصــوديوم والكالســيوم والتفاعــل بينـهمــا علــى محصــول الطمــاطم والتركيب الكيماوى للثمار

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**** قسم تغذيه النبات -مركز البحوث الزراعية –معهد الاراضي والمياه والبيئه**

فى تجربة مزارع غذائية بكلية الزراعة،جامعة المنصورة فى موسمين متتاليين (٢٠١٠و ٢٠١١) تمت دراسة أثر مستويات النيتروجين (٣٠.٠ و ١٥٠.٠ جزء فى المليون من المحلول المغذى) والصوديوم (٠.٠ و ١٦.٠ ملليمكافئ /لتر فى المحلول المغذى) و الكالسيوم (٠.٠ و ٥.٠ و ١٠.٠ و ٢٠.٠ ملليمكافئ كالسيوم لكل لتر من المحلول المغذى) على محصول الثمار و محتوى تلك الثمار من النيتروجين والفوسفور والبوتاسيوم و صور الكالسيوم .

من أهم النتائج المتحصل عليها مايلى :-

- زياده معنوية في عدد ثمار الطماطم قدرت بـ ١٩.٧٢% في الموسم الاول و ١٩.٤٩% في الموسم الثاني ، بينما زياده المحصول الكلى كانت ١٨.٨٩و ١٨.٦٤% للموسم الاول والثاني علي التوالى، و كذلك اختلف معدل وزن الثمره معنويا (٢٩.١٢ و ١٥.٤١ %زيادة فى الموسم الأول والثانى على الترتيب) بسبب زياده النيتروجين فى المحلول المغذى من ٣٠ الي ١٥٠ جزء فى المليون
- ٤ملليمكافئ/لتر صوديوم أدت إلى خفض المحصول الكلى لثمار الطماطم بمقدار ٥.١٦ الموسم الأول وزيادة طفيفة عن تلك (٥.٥ %) فى الثانى.
- المحتوى النيتروجينى فى ثمارالطماطم زاد من ٢.٥٣ الي ٣.٠٩% (٢٢.١٣ % زيادة) فى الموسم الأول ومن٢.٧ الى٣.١٩%(١٨.١٥ % زيادة) فى الموسم الثانى بسبب زيادة النيتروجين فى المحلول المغذي من ٣٠ الي ١٥٠ جزء فى المليون .
- ٤ ملليمكافئ صوديوم /لتر فى المحلول المغذى أدت إلى خفض المحتوى النيتروجين والفوسفور والبوتاسى فى ثمار الطماطم مقارنة بالكنترول.
- المحتوي البوتاسى لثمار الطماطم قل مع زياده الكالسيوم في المحلول المغذي حتى ٢٠ملليمكافئ /لترفي كلا الموسمين (٥.٥٦ و ٤.٧٩ % نقص مقارنة بالكنترول فى الموسم الأول والثانى على التوالى) .
- لم يلاحظ تأثير معنوى ولا إتجاه ثابت للكالسيوم الكلى كنتيجة لزيادة مستوى النيتروجين من ٣٠ إلى ١٥٠ جزء فى المليون فى كلا الموسمين .
- الكالسيوم المستخلص بكلوريد الصوديوم أخذ الأتجاة المعاكس للكالسيوم الكلى ، حيث زاد الكالسيوم المستخلص بكلوريد الصوديوم فى ثمار طماطم بـ ٥.٠٧% فى الموسم الأول ونقص بما يعادل ٤.٧٢ % بسبب نفس زيادة من النيتروجين من ٣٠-١٥٠ جزء فى المليون .
- الكالسيوم المستخلص بكل من حمض الخليك وحمض الهيدروكلوريك وكذا المتبقى أظهروا اتجاه ثابت كنتيجة لزيادة مستوى النيتروجين فى كلا الموسمين.
- ٤ ملليمكافئ صوديوم /لتر أدت إلى زيادة معنوية فى كافة صور الكالسيوم الموجودة فى ثمار الطماطم فى كلا الموسمين مقارنة بحالة عدم اضافة الصوديوم .
- ظهرت زيادة في الكالسيوم المستخلص بالإيثيلين مع زيادة للكالسيوم فى المحلول المغذى حتى ١٠ ملليمكافئ/لتر تلاها نقص طفيف بزيادته إلى ٢٠ ملليمكافئ / لتر فى كلا الموسمين
- وجدت زيادة كبيرة فى الكالسيوم المستخلص بكلوريد الصوديوم بزيادة الكالسيوم فى المحلول المغذى من صفر إلى ٥.٠ ملليمكافئ / لتر(من ٨٨٣.٦ الى ١٢٥٣.٤٨ ومن ٩٢٦.٧٤ الي١٢٢٢.٩٠ فى الموسم الأول والثانى على التوالى)، ومعدل إنخفاض قليل (من ١٣٩٦.٢٥ الي١٢٩٥.٦٥ومن ١٣٣٠.٢٦ الي١٢٥٦.٩٨فى الموسم الأول والثانى على التوالى) لوحظت فيما يتعلق بالكالسيوم المستخلص بكلوريد الصوديوم عند زيادة مستوى الكالسيوم من ١٠ الى ٢٠ ممليمكافئ/لتر فى المحلول المغذى .
- فى كلا الموسمين اوكسلات الكالسيوم زادت بشكل ملحوظ بزيادة مستوى الكالسيوم من ٠.٠ الى ١٠ ممليمكافئ/لتر فى المحلول المغذى وقدرت هذة الزيادة بـ ٢٧٦.٤٩ الي٢٧٥.٣٣% فى الموسمين الأول والثانى على التوالى .

قام بتحكيم البحث

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