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EFFECT Of CALCIUM CONCENTRATION IN NUTRIENT SOLUTION AND ITS APPLICATION TIME ON TOMATO FRUIT COMPOSITION .

Labib, G. *; Z. M. El-Sairafy * and Amira A. Kasem**

*** Soils Dept., Fac. of Agriculture, Mansoura Univ., Egypt.**

**** Plant Nutrition Dept., Soil, Water and Enviro. Res, Inst, Agric. Res. Center.**

ABSTRACT

A greenhouse 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 Ca concentration (0.0, 5.0, 10.0 and 20.0 meq / l) in nutrient solution and its application time (pre flowering and post flowering) on tomato fruit composition. Combination between the studied factors levels comprise eight treatments which were arranged in a split block design with 3 replicates . All treatments were studied in the presence of N – concentration at rate of 150 ppm .

The obtained results can be summarized in the following :-

Total calcium content of tomato fruit was increased by 19.64 % in the first season and 6.06 % in the second season as a result of post- flowering application of calcium .

Relatively higher increases were found in Etha-Ca (8.01 %) and H2O- Ca (7.99 %) in the first season compared with that of the second season (1.87 for Etha-Ca , 1.93 for H2O- Ca) due to pre flowering Ca application .

Pre – flowering calcium application reduced Na Cl- Ca (6.82 and 5.94%) ,HAC- Ca (6.38 and 11.54 %) and HCl- Ca (3.19 and 9.34 %) in tomato fruits in both seasons.

Increasing calcium levels up to 10.0 meq /l significantly increased total calcium of tomato fruits, while rising calcium level from 10.0 to 20.0 meq /l significantly decreased total calcium content of tomato fruitsin the first season . In the second season, increasing calcium levels up to 10.0 meq /l increased total calcium of tomato fruits but the difference in that trait between treatments of 5.0 and 10.0 meq /l is not detectable . So calcium level of 20.0 meq /l reduced total calcium content by 9.21 % compared with treatment of 10.0 meq /l in the second season .

Post-flowering application of Ca at a rate of 5.0 meq/l have the highest value of total Ca in tomato fruits(4446.9 and 3895.5 ppm in the first and second seasons).

Appling 5.0 meq / l treatment achieved the highest values of Eth- Ca in both seasons (155.2 and 169.4 ppm for the firs and second season , respectively).

Increasing Ca level above 5.0 meq /l significantly decreasd Eth – Ca in bothseason in tomato fruits .In spite of increasing H2O – Ca form significantly by adding 5.0 meq / l than that of control (60.0 and 65.455 increase in the first and second season) . Significantly decrease (comparing to 5.0 meq / l treatment) with increasing Ca level behind that was found .

NaCl – Ca in tomato fruits refer to Ca in pectate form which caused fruit hardness 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) .

Na Cl – Ca represent the large portion of Ca in tomato fruit . Post-flowering application of 5.0 meq Ca/l maximize of NaCl- Ca , where 3440 and 2884 ppm Ca were found in this form in the first and second season, respectively .

HAC-Ca {Calcium phosphate and Calcium carbonate} in tomato fruits have a strongly increasing trend by increasing Ca level in nutrient solution from 0.0 Ca

addition to 5.0.0 meq /l. Approximately plateau trend was found in HAc-Ca content of tomato fruits by increasing Ca in nutrient solution up to the highest level used (20.0 meq / l).

little increases, but significant (the least significant differences are 3.4 and 2.44 for the first and second season respectively) in tomato fruit calcium oxalate due to increasing Ca in nutrient solution from 5.0 to 20.0 meq /l . This increase amounted by one tenth, approximately, of that increase which have been happened in that trait due to Ca level increase of nutrient solution from 0.0 to 5.0 meq / l .

Higher increasing rate was found in HCl – Ca form in tomato fruit due to calcium addition than that of any other form .

Calcium silicate of tomato fruit treated with 10.0 meq Ca /l did not significantly differ than that of treated with 5.0 meq Ca/l . Treatment of 20.0 meq Ca /l significantly decreased these Ca forms compared with that of 5.0 meq Ca /l treatment.

Post - flowering application of Calcium enhanced N uptake which in turned N content of tomato fruit in both seasons . N content of tomato fruit was increased by 3.19 and 3.08 % in the first and second season, respectively . The least significant differences between time application treatment means were 0.05 and 0.06 for the first and second season respectively . So post- flowering Ca application treatment have a higher mean of phosphorus content (0.436 and 0.427 %in the first and second season , respectively).

Ca application time did not significantly affect potassium content of tomato fruit .

Pre – flowering Ca application led to an increase in each of Mg and Na in tomato fruits (26.9 and 7.35 %increase in Mg content and Na content , respectively) . Little change in nitrogen content of tomato fruit as affected by Ca level in nutrient solution was found in both seasons, where it was ranging between 3.16 to 3.256 % in the first season and between 3.28 to 3.39 % in the second season.

post- flowering Ca application at 10.0 meq/l in nutrient solution recorded the highest value in both seasons (3.45 and 3.58 % in the first and second season, respectively).

2.05 and 2.09 % decrease in tomato fruit phosphorus content was found due to nutrient solution Ca increase from 10.0 meqto 20.0 meq /l in the two successive seasons.

In both seasons 20.0 meq / l Ca tended to decrease (2.44 and 3.69 % decrease in the first and second season, respectively) potassium content of tomato fruit .

Mg content of tomato fruit was decreased by Ca addition in nutrient solution, whenever no stedy trend with increasing Ca level in any season was found .

It is worthy to identify that pre- flowering Ca application at 10.0 meq/l recorded the highest Mg content of tomato fruit (528 and 538 ppm for the first and second season , respectively)

The lowest values of sodium content of tomato fruit were found at 0.0 Ca level in both seasons . The highest values in both seasons (178 ppm for the first season and 173 ppm for the second one) were obtained due to 5.0 meq Ca /l treatment .

10.0 and 20.0 meq Ca /l treatment means of sodium content were lower than that of 5.0 meq Ca /l treatment by 17.42 and 28.65 %in the first season, corresponding values in the second season were 17.63 and 28.90 %

Keywords: Calcium , Nutrient solution ,Sandy texture,Flowering 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 including ascorbic acid, vitamin E, beta-carotene, xanthopyll and flavonoides. Lycopene, the predominant carotenoid in tomatoes, is hypothesized to mainly mediate the health benefits of tomato products.

Calcium in tomato fruit is very important, It is one of the vital elements that play a key role in plant growth and fruit development ,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 plays a decisive role in the maintenance of cell membrane integrity and membrane permeability; activating a number of enzymes for cell mitosis division, and possibly detoxifying the presence of heavy metals in tissue(Jones, 1999).

Times of Ca application were selected as Aghofack-Nguemezi and Tatchago (2010). They stated that the most striking features of field application of fertilizers containing Ca and/or Mg were increased in the duration of flowering of plants .

Urea was shosen as a N source due to many auther recommendations such as Geo *et al*., (1996), Masuda *et al*., (1996) and Heeb *et al*., (2005b). They stated that ammonium-N or organic nitrogen was assimilated faster in tomato plant results in an improved fruit quality and flavor.

Blossom end rot (BER) in tomato is an often-obsorved as physiological disorder resulting from a lower supply of Ca and a local Ca deficiency in the fruit (Bangerth, 1979) BER disorder mainly is caused by differences in genetic compositions rather than in Ca nutrition, where a higher Ca^{2+} concentrations in fruit affected by BER was found than that of normal fruit (Nonami *et al.*, 1995). So low temperature during winter or very low ambient humidity during spring-summer, could have affected calcium uptake and/or calcium distribution within the plant. Those stresses would also have masked any beneficial effect of Ca on salinized plants (**Soria *et al.,* 2002)**.

Calcium in tomato fruit exists as a number of ca compounds. This study aimed to assess the external Ca application levels and it's application time on different Ca forms and N, P, K, Mg and Na content of tomato fruit .

MATERIALS AND METHODS

A greenhouse pot 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 daily 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 block design was used, where two application time (pre-flowering and post-flowering) were allocated in main plots and four Ca levels(0.0,5.0,10.0,20.0meq/ l) were in sub plot . Combination between the studied factors levels comprise eight treatments , each one was replicated three times .

Times of Ca application were selected as Aghofack-Nguemezi and Tatchago (2010). They stated that the most striking features of field application of fertilizers containing Ca and/or Mg were increased in the duration of flowering of plants .

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 2010and 2011, three seedlings 45 days old of tomato plant (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.

Hoagland solution (0.150 g urea-N , 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 cooper 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 Ca concentrations (0.0, 5.0, 10.0and 20.0 meql L^{-1})were prepared and used for this experiment .

Urea was shosen as a N source due to many auther recommendations such as Geo *et al*., (1996), Masuda *et al*., (1996) and Heeb *et al*., (2005b). They stated that ammonium-N or organic nitrogen was assimilated faster in tomato plant results in an improved fruit quality and flavor.

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

The analytical procedure of Ca fractionation was done according to Ohat *et al*;1970,where 10 g samples of fresh fruit tissue in tomato friuts were homogenized in 30 ml 80% ethanol . The homogenized samples were shaken for 18 h at 300 C and then centrifuged at 8000 rpm for 10 min. The supernatants were collected. The residue was washed with 20 ml ethanol (80%), where, mixed for 2 h and centrifuged . This was replecated 3 times . The supernatants from the extraction and washing were made up to 100 ml for the determination of Ca fraction 1 (ethanol – Ca) .

The residue was extracted consecutively following similar procedures with distilled water, 1 mol / L. NaCl , 2% acetic acid, 0.6 % Hcl for determination of Calcium fraction 2 (H2 O- Ca), Ca fraction 3 (NaCl – Ca), Calcium fraction 4 (HAc-Ca) and Calcium fraction 5 (Hcl – Ca), respectively.
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).

The calcium compound of fraction 1-5 were mainly regarded as Ca (NO3)2 and CaCl2 (1), soluble organic calcium such as Amino acid Calcium salts(2), Calcium pectate (3), Calcium phosphate and Calcium carbonate (4) and Calcium oxalate (5).

Calcium concentration in the extracts was determined by atomic absorpation spectophotometry . Three replications per treatment were included.

Point four gm of plant 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 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

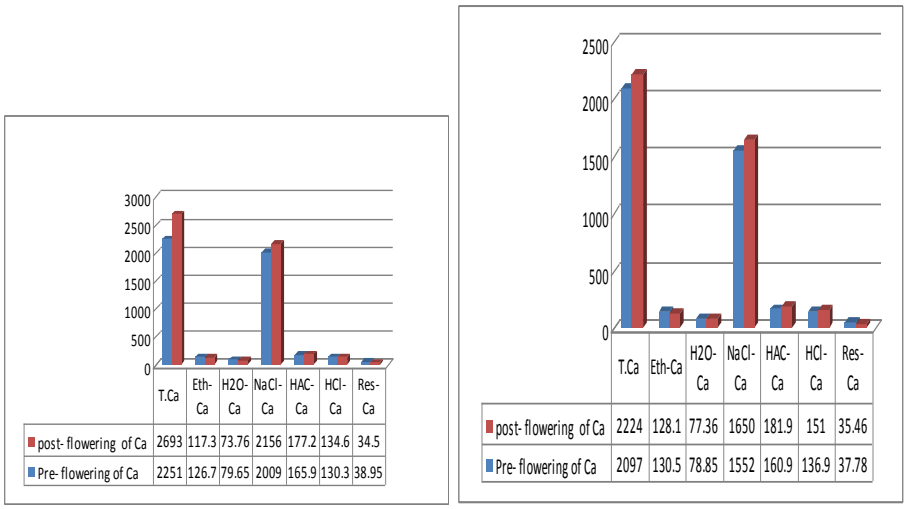
Data plotted in Fig (1) illustrate the effect of calcium application time on calcium forms of tomato fruit. Data reveal that total calcium content of tomato fruit was increased (19.64 % in the first season and 6.06 % in the second season) as a result of post- flowering application of calcium .

Relatively higher increases were found in Etha-Ca (8.01 %) and H2O-Ca (7.99 %) in the first season compared with that of the second season (1.87 for Etha-Ca , 1.93 for H2O- Ca) due to pre flowering Ca application .

Res- Ca increments amounted by 2.90 % in the first season and 6.54 in the second season due to pre-flowering Ca application. and for Res- Ca, respectively).

Pre – flowering calcium application reduced Na Cl- Ca (6.82 and 5.94%) ,HAC- Ca (6.38 and 11.54 %) and HCl- Ca (3.19 and 9.34 %) in tomato fruits in both seasons.

Concerning to calcium levels effect on total calcium content of tomato fruits, data plotted in Fig 2 stated that increasing calcium levels up to 10.0 meq /l significantly increased total calcium of tomato fruits, while rising calcium level from 10.0 to 20.0 meq /l significantly decreased total calcium content of tomato fruits(LSD = 55.59) in the first season .



First season **Second season**

Fig 1: Effect of calcium application time on Calcium forms of tomato fruits of the first and second seasons .

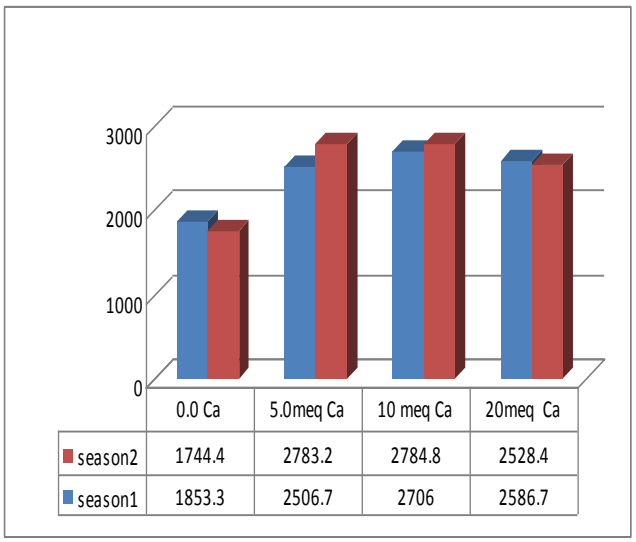


Fig 2 : Effect of calcium levels on total Calcium content of tomato fruits

In the second season, increasing calcium levels up to 10.0 meq /l increased total calcium of tomato fruits but the difference in that trait between treatments of 5.0 and 10.0 meq /l is not detectable (2783.2 for treatment of 5.0 meq /l and 2784.8 for treatment of 10.0 meq /l , where LSD between treatment means is 55.59 . So calcium level of 20.0 meq /l reduced total

calcium content by 9.21 % compared with treatment of 10.0 meq /l in the second season . These results are in agreement with that of Paiva et al., (1998). They stated that, increasing Ca level in nutrient solution led to increase calcium level of tomato fruit, but decrease carotene and lycopene content

Data in Table 1 pointed out that post-flowering application of Ca at a rate of 5.0 meq/l have the highest value of total Ca in tomato fruits(4446.9 and 3895.5 ppm in the first and second seasons). The least significant differences between treatment means was 82.6 in the first season and 78.62 for the second season .

Table 1: Relation ships between Calcium levels and its application time on forms of tomato fruit.

Treat . Character		Preflowering Ca application				Postfloweing Ca application				Interaction LSD
		0.0meq / l	5.0 meq / l	10.0meq / l	20.0meq / l	0.0meq / l	5.0meq / l	10.0meq / l	20.0meq / l	
T.Ca	1st	1923	1771.4	2638.6	3848.9	1923	4446.9	1433.8	2969.7	82.60
	2nd	1750.6	1672	2354.1	2348.5	1750.6	3895.5	1610.9	1938.1	78.62
Eth-Ca	1st	95.2	82.3	132.7	196.6	95.2	228.1	60.2	85.7	228.1
	2nd	103.9	84.8	136.7	196.5	103.9	234.9	91.2	82.3	234.9
H2O-Ca	1st	59.4	48.5	83.8	126.9	59.4	147.4	35.7	52.5	1.2
	2nd	58.8	48	83	125.6	58.8	145.9	52.5	52.2	1.4
NaCl-Ca	1st	1530	1414	2065	3027	1530	3440	1166	2488	58.0
	2nd	1349	1312	1784	1763	1349	2884	1215	1152	38.0
HAC-Ca	1st	122.5	103.7	170.3	247.1	122.5	319.6	78.2	188.5	0.25
	2nd	118.8	100.6	165.2	139.6	118.8	309	117.1	182.7	25.09
HCl-Ca	1st	95.6	73.1	134.5	218	95.6	259.7	43.8	139.3	0.49
	2nd	100.4	76.8	141.2	90.1	100.4	272.7	84.4	146.5	3.44
Res-Ca	1st	20.3	49.8	52.3	33.4	320.3	52.1	49.9	15.7	0.14
	2nd	19.7	49.8	47.9	33.7	19.7	49	50.7	22.4	2.22

Regarding to Ca levels effect on Eth-Ca Data of Fig 3 outlined that 5.0 meq / l treatment achieved the highest values of Eth- Ca in both season (155.2 and 169.4 ppm for the firs and second season , respectively). Increasing Ca level above 5.0 meq /l significantly decreasd Eth – Ca in both season (LSD between Ca treatment means in the first and second seasons are 1.22 and 1.62 respectively).

Higher values of Eth – Ca were also found in the second season than that of the first season .

Eth-Ca was significantly affected by application time- Ca levels interaction, where post-flowering application of Ca at a rate of 5.0 meq/l of nutrient solution have the highest value of Eth-Ca in the secons season (228.1 and 234.9 ppm) Table 1 .

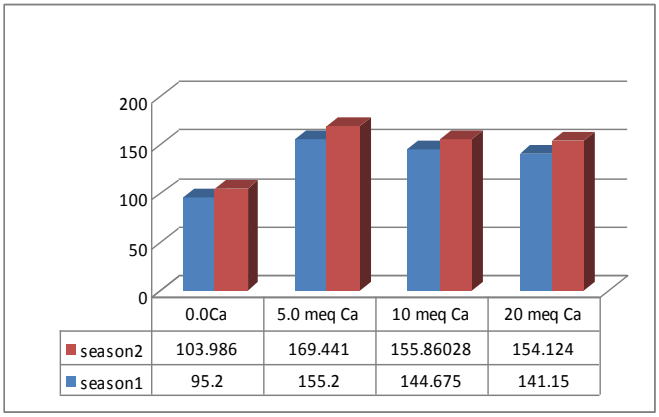


Fig 3 : Effect of calcium levels on Eth-Calcium of tomato fruits

In spite of increasing H2O – Ca form significantly by adding 5.0 meq / l than that of control (60.0 and 65.455 increase in the first and second season). Significantly decrease (comparing to 5.0 meq / l treatment) by increasing Ca level behind that was found may be due to the effect of high salt concentrations which increase the membrane permeability of plant roots, Kaya *et al*., (2002). H2O – Ca in both season still higher than that of 0.0 Ca treatments . H2O – Ca in the first season significantly seems to be equal or higher than that of second season .

Data in Table 1 reveal that H_2O – Ca was significantly responded to application time- Ca level interaction where, the least significant differences between the studied treatment means were 1.2 and 1.4 for the first and second season respectively .

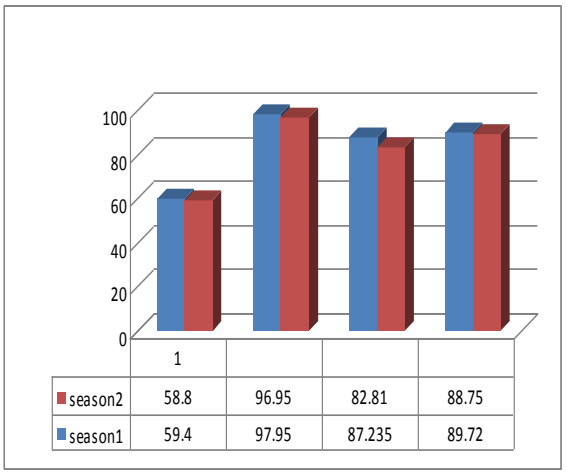


Fig 4 : Effect of calcium levels on H_2O-Calcium of tomato fruits

NaCl – Ca in tomato fruits refer to Ca in pectate form which caused fruit hardness. As it is shown in Fig 5 , 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 (The least significant differences between treatment means are 58.0 and 38.0 in the first and second season, respectively) .

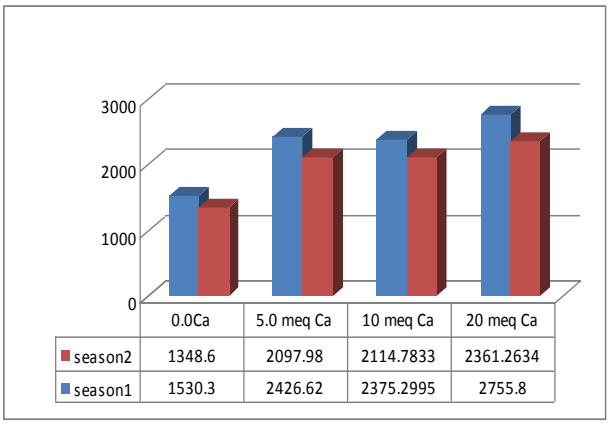


Fig 5 : Effect of calcium levels on NaCl-Calcium of tomato fruits

Approximately plateau trend was found in NaCl – Ca content of tomato fruits by increasing Ca in nutrient solution from 5.0 to 10.0 meq / l . A plateau refer to the adequate concentration of that nutrient in growth media. 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.

A noticeable increase in NaCl – Ca content by increasing Ca in nutrient solution from 10.0 to 20.0 meq / l, this may led to lowr growth rate comparing to Ca transformation rate in plant supplied with a huge amount of Calcium. Similar results were obtained by Bozkur *et al*., (2008) . They outlined that Ca pectate in tomato fruit significantly increased with increasing Ca concentration in the nutrient solution and foliar application. From table 1 data Na Cl – Ca represent the large portion of Ca in tomato fruit . Post-flowering application of 5.0 meq Ca/l maximize NaCl- Ca , where 3440 and 2884 ppm Ca were found in this form in the first and second season, respectively .

HAC-Ca {Calcium phosphate and Calcium carbonate} content of tomato fruits as affected by Ca level supply are shown in Fig 6. HAc-Ca in tomato fruits have a strongly increasing trend by increasing Ca level in nutrient solution from 0.0 Ca addition to 5.0.0 meq /l. Approximately plateau trend was found in HAc-Ca content of tomato fruits by increasing Ca in nutrient solution up to the highest level used (20.0 meq / l) . Very little differences between Ca treatment means in that trait in both seasons . these results are in agreement with that of . Peyvast *et al.,* (2009). They stated that tomato crops fertilized with 6 mmolL-1 calcium nitrate and 4 mmolL-1 potassium phosphate have a greater quality.

Significant interaction was found between application time and levels of Ca where the treatment of post- flowering application of Ca at a rate of 5.0 meq/ l give the highest level of HAC-Ca in both season (319.6 and 309.0 ppm), Table 1 .

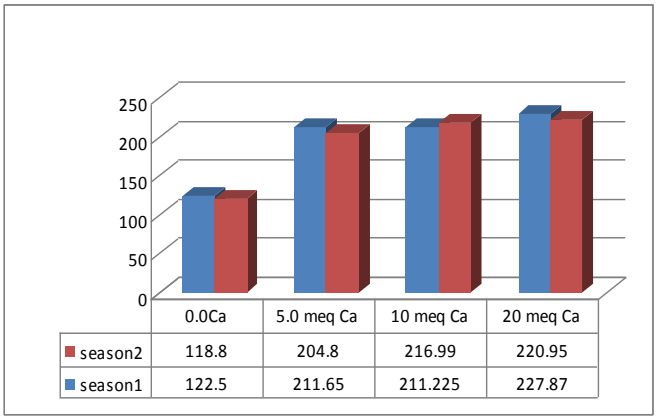


Fig 6 : Effect of calcium levels on HAC -Calcium of tomato fruits

Tomato fruit calcium oxalate as affected by Ca levels was shown in Fig 7 . In both seasons Ca oxalate was increased with increasing Ca level from 0.0 to 5.0 meq /l in nutrient solution, these increases appreciated by 72.4 and 74.1 % in the first and second season , respectively . Little increases, but significant (the least significant differences are 3.4 and 2.44 for the first and second season respectively) in tomato fruit calcium oxalate due to increasing Ca in nutrient solution from 5.0 to 20.0 meq /l (7.7% and 7.9% increase in the first and second season respectively) . This increase amounted by one tenth, approximately, of that increase which have been happened in that trait due to Ca level increase of nutrient solution from 0.0 to 5.0 meq / l .

Higher increasing rate was found in HCl – Ca form in tomato fruit due to calcium addition than that of any other form .

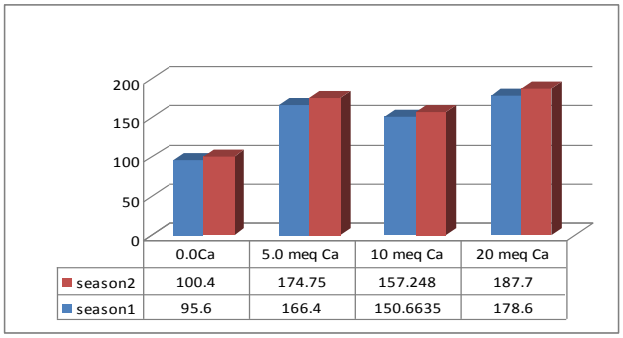


Fig 7: Effect of calcium levels on HCl -Calcium of tomato fruits

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 Fig 8. Tomato fruit calcium silicate in both season took the same manner. It was increased from 20.3 to 50.95 ppm and from 19.7 to 49.4 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 5.0 meq Ca/l . Treatment of 20.0 meq Ca /l significantly decreased these Ca form compared with that of 5.0 meq Ca /l treatment, where the least significant differences for the first and second seasons were 2.43 and 2.22 , respectively

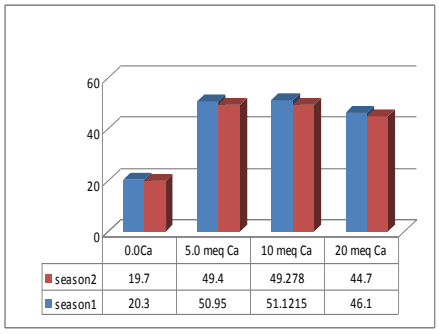


Fig 8 : Effect of calcium levels on Res. -Calcium of tomato fruits

Data of Fig 9 reveal Calcium application time effects on N,P,K, Mg and Na of tomato fruit (Dry weight basis).

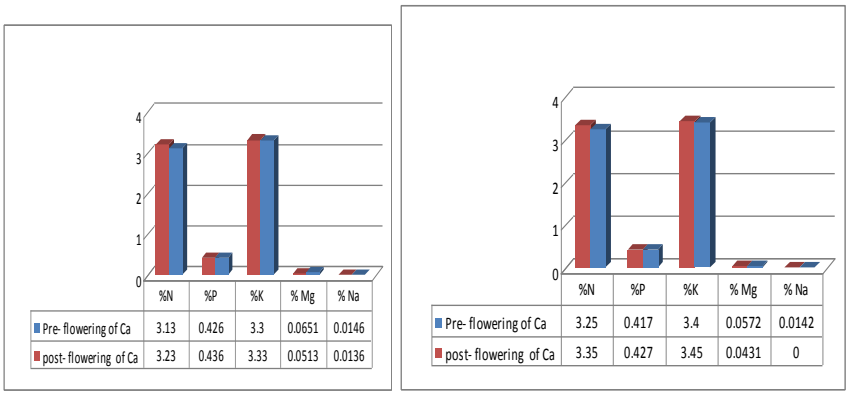
As it is shown in the Fig, Post - flowering application of Calcium enhanced N uptake which in turned in N content of tomato fruit in both seasons . N content of tomato fruit was increased by 3.19 and 3.08 % in the first and second season, respectively . The least significant differences between time application treatment means were 0.05 and 0.06 for the first and second season respectively .

Ca application time affected P content of tomato fruits, where post-flowering Ca application treatment have a higher mean of phosphorus content (0.436 and 0.427 %in the first and second season , respectively) than that of pre- flowering Ca application treatment (0.426 and 0.417 % in the first and second season , respectively). The difference between time of application treatment means is significant .

Ca application time did not significantly affect potassium content of tomato fruit , in spite of that post- flowering application time treatment have a slight increase in that trait than that of the other treatment . Slight increase in potassium content of tomato fruit was notice in the second season than that of the first one .

Pre – flowering Ca application led to increase each of Mg and Na in tomato fruits (26.9 and 7.35 %increase in Mg content and Na content , respectively) . These increment statistically characterize by significant(the least significant differences were 5.2 and 1.2 for Mg and Na , respectively) in

the first season . Mg and Na in the second season took a similar trend that was taken in the first one, where Mg and Na in tomato fruit was increased by 32.71 and 7.58 % due to pre- flowering of Calcium compared with post-flowering application .



First season **second season**

Fig (9) : Effect of calcium application time on N, P, K, Mg and Na of tomato fruits

Fig 10 illustrate Ca level effect on N content of tomato fruits ,where Little change in nitrogen content of tomato fruit as affected by Ca level in nutrient solution was found in both seasons, where it ranging between 3.16 to 3.256 % in the first season and between 3.28 to 3.39 % in the second season. 10.0 meq Ca/l treatment in both seasons have a superiority in this regard, where it has highest N content in tomato fruits (3.265 and 3.39 % bin the first and second season, respectively. 20.0meq /l teded to decrease N content of tomato fruits by 2.83and 4.28 % compared with that of 10.0meqCa/l . These results are in acceptable trend with that of Yokafi *et al*., (2008). They investigated the effects of CaCl2 on yield and quality of greenhouse grown tomato, where Membrane permeability was impaired with increasing CaCl2 concentrations. So N concentrations was decreased with increasing CaCl2 salt concentrations.

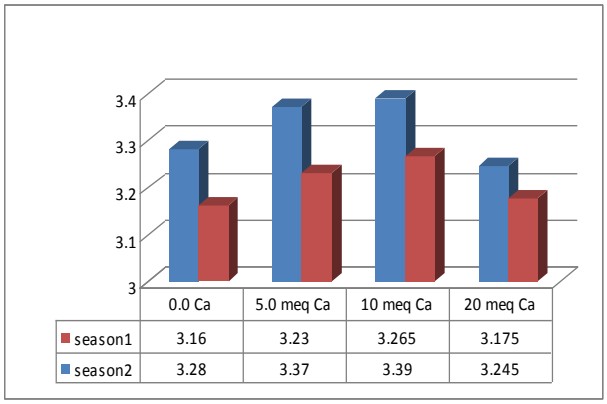


Fig (10) : Effect of calcium levels on N content of tomato fruits

Data in Table 2 reveal Ca application time – Ca levels interaction on N ,P, K, Mg and Na in tomato fruit , where a significant interaction effect was found between Ca application time and Ca level regarding to N content of tomato fruit , where post- flowering Ca application at 10.0 meq/l in nutrient solution recorded the highest value in both season (3.45 and 3.58 % in the first and second season, respectively).

Table 2 : Calcium levels and its application time on N ,P, K, Mg and Na in tomato fruit .

Char. / Treat.		N%		P%		K%		Mg ppm		Na mg.kg	
		1st	2nd	1st	2nd	1stt	2nd	1st	2nd	1st	2nd
Pre-flowering	0.0 meq/l Ca	3.16	3.28	0.429	0.420	3.36	3.46	462	471	113	110
	5.0 meq/l Ca	3.27	3.40	0.439	0.430	3.41	3.51	459	468	184	179
	10.0 meq/l Ca	3.08	3.20	0.421	0.412	3.24	3.34	528	538	155	150
	20.0 meq/l Ca	2.99	3.10	0.413	0.404	3.17	3.27	495	510	133	129
Post-flowering	0.0 meq/l	3.16	3.28	0.429	0.420	3.06	3.15	462	471	113	110
	5.0 meq/l Ca	3.19	3.34	0.437	0.446	3.36	3.46	441	451	172	167
	10.0 meq/l Ca	3.45	3.58	0.459	0.449	3.53	3.64	345	386	139	135
	20.0 meq/l Ca	3.36	3.39	0.448	0.439	3.35	3.54	405	413	121	117
LSD for 0.05		**0.075**	**0.080**	**0.004**	**0.005**	**0.11**	**0.12**	**5.77**	**4.03**	**2.24**	**2.62**

Fig 11 reveal Ca application levels in nutrient solution effects on P content of tomato fruit . In the first season phosphorus content of tomato fruit was increased by 4.29 % with the first increase in Ca content of nutrient solution (5.0 meq/l) while phosphorus content of tomato fruits was significantly increased up to the second increment of Ca content in nutrient solution (10.0 meq/l).

In tomato fruit phosphorus contentdecrease due to nutrient solution Ca increase from 10.0 meqto 20.0 meq /l in the two successive seasons. Similar trend was illustrated by Gunes *et al*., (1998). They reported that P content of tomato leaves was decreased with increasing Ca in the nutrient solution. So Ca application decreased P concentrations of tomato fruit grown in a greenhouse Bozkur *et al*., (2008) . Post – flowering application of Ca at a level of 10.0 meq/l recorded the highest phosphorus content of tomato fruit in both season, 0.459 and 0.449 %for the first and second season, Table 2.

K content of tomato fruits as affected by Ca application levels are shown in Fig 12. Potassium content of tomato fruits was increased as nutrient solution Ca increase up to 10.0 meq /l, mean while the difference between 5.0 and 10.0 meq Ca /l treatment means is not significant (LSD = 0.08 and 0.76 for the first and second season, respectively).

In both season 20.0 meq / l Ca tended to decrease (2.44 and 3.69 % decrease in the first and second season, respectively) potassium content of tomato fruit . 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 mM)in the nutrient solution.

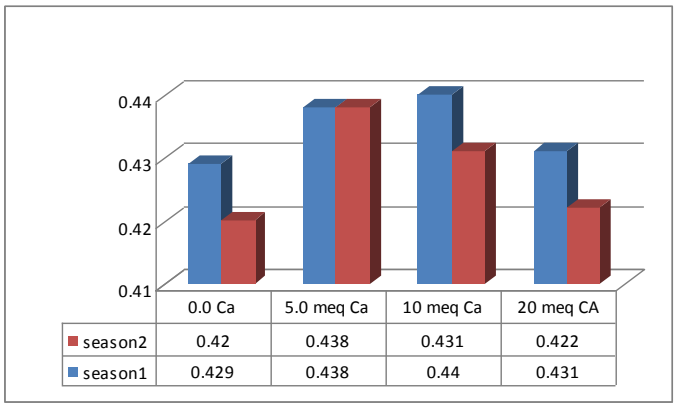


Fig (11) : Effect of calcium levels on P content of tomato fruits

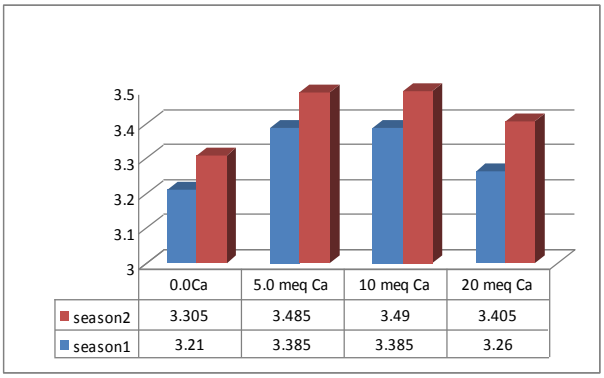


Fig (12) : Effect of calcium levels on K content of tomato fruits

The highest values of K content of tomato fruit (3.53 and 3.46 %) were obtained with post – flowering Ca application of 10.0 meq /l , in both seasons.

Data plotted in Fig 13 reveal Ca levels effect on Mg content of tomato fruit . Data declared the significant effect of Ca treatment on Mg content of tomato fruit . Mg content of tomato fruit was decreased by Ca addition in nutrient solution as it is shown in the Fig, whenever no steady trend with increasing Ca level in any season was found . This trend can be explained by cationic antagonism or withdrawal of Mg from the nutrient solution in order to maintain the balance between cations against the increasing Ca**.** Carvajal *et al*., (1999) result took the same way , where increasing levels of external Ca (0.5 to 10 mM in nutrient solution) resulted in decreased Mg uptake.

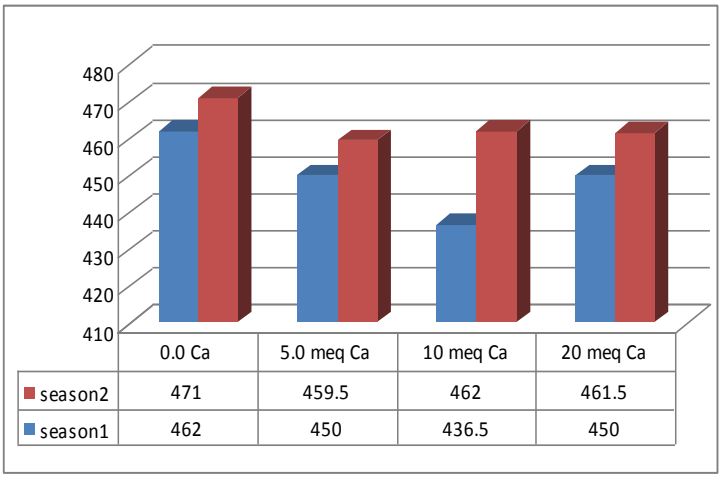


Fig (13) : Effect of calcium levels on Mg content of tomato fruits

It is worthy to identify that pre- flowering Ca application at 10.0 meq/l recorded the highest Mg content of tomato fruit (528 and 538 ppm for the first and second season , respectively), Table 2 .

Fig 14 show Ca treatments effect on tomato fruit sodium. Data pointed out that the lowest values of sodium content of tomato fruit were found at 0.0 Ca level in both season . The highest values in both seasons (178 ppm for the first season and 173 ppm for the second one) were obtained due to 5.0 meq Ca /l treatment .

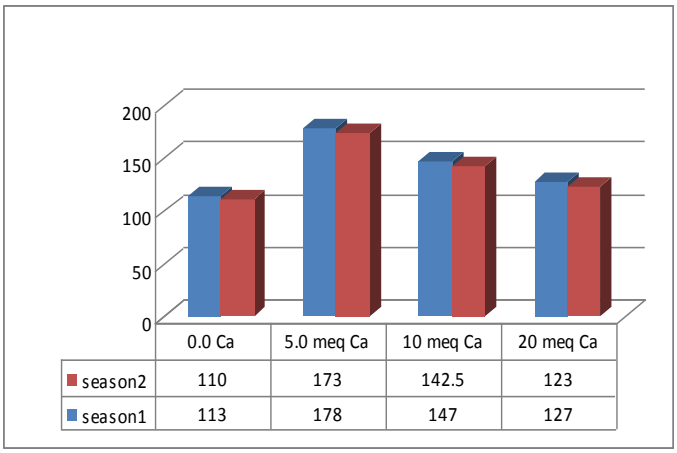


Fig (14) : Effect of calcium levels on Na content of tomato fruits

The antagonistic effect between Ca and Na as tomato fruit sodium content decrease was notice by adding Ca in nutrient solution at a concentration rate of 10 or 20.0 meq/ l . 10.0 and 20.0 meq Ca /l treatment means were lower than that of 5.0 meq Ca /l treatment by 17.42 and 28.65 %in the first season, corresponding values in the second season were 17.63

and 28.90 % . The least significant difference between Ca level treatment means were 2.58 in the first season and 3.86 for the second season. 184 and179 ppm Na were recorded as higher content of tomato fruit Sodium due to Ca application at 5.0 meq/l at pre- flowering stage , in the first and second season, respectively, Table 2 .

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تـأثير مستويات الكالسيوم فى المحلول المغذى وميعاد اضافته على تركيب ثمار الطماطم

جمعه لبيب* ، زكريا مسعد الصيرفى* و أميرة عبدالرءوف قاسم**

*** جامعة المنصورة_كلية الزراعة_قسم الأراضى.**

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

فى تجربة بيوت محمية باستخدام المحاليل الغذائية بكلية الزراعة،جامعة المنصورة فى موسمين متتاليين (٢٠١٠و ٢٠١١) تمت دراسة أثر مستويات الكالسيوم (٠.٠ و ٥.٠ و ١٠.٠ و ٢٠.٠ ملليمكافئ كالسيوم لكل لتر من المحلول المغذى) وميعاد إضافة (قبل التزهير و بعد التزهير) على صور الكالسيوم فى ثمار الطماطم وكذلك محتوى تلك الثمار من النيتروجين والفوسفور والبوتاسيوم والماغنسيوم والصوديوم

من أهم النتائج المتحصل عليها مايلى :-

- محتوى ثمار الطماطم من الكالسيوم الكلى زاد بما يعادل ١٩.٦٤ % فى الموسم الأول وبما يعادل ٦.٠٦ % فقط فى الموسم الثانى كنتيجة لإضافات الكالسيوم عقب التزهير .

- زيادة كبيرة نسبيافى الكالسيوم المستخلص بالإيثانول (٨.٠١ %) وكذلك فى الكالسيوم المستخلص بالماء (٧.٩٩ %) فى الموسم الأول مقارنة بمثيلاتها فى الموسم الثانى (١.٨٧ و ١.٩٣ % على الترتيب) ز
- إضافة الكالسيوم قبل التزهير أدت إلى نقض الكالسيوم المستخلص بكلوريد الصوديوم بما يعادل ٦.٨٢ و ٥.٩٤ % ونقص المستخلص بحامض خليك بما يعادل ٦.٣٨ و ١١.٥٤ % ونقص المستخلص بحمض الأيدروكلوريك بما يعادل ٣.١٩ و ٩.٣٤ % لكل من الموسم الأول والثانى على الترتيب .
- زيادة مستوى الكالسيوم حتى ١٠.٠ ملليمكافئ أدى إلى زيادة الكالسيوم الكلى زيادة معنوية فى الثمار . وزيادته من ١٠.٠ إلى ٢٠.٠ ملليمكافئ أدى إلى نقص معنوى فى الكالسيوم الكلى للثما وذلك فى الموسم الأول . أما فى الموسم الثانى زاذ الكالسيوم الكلى فى الثمار زيادة معنوية بزيادة الكالسيوم المضاف إلى ١٠.٠ ملليمكافئ ولكن الفرق فى الكالسيوم الكلى بين مستويى الكاليوم ٥.٠ و ١٠.٠ ملليمكافئ لم يكن ملحوظا .وزيادة مستوى الكالسيوم إلى ٢٠.٠ ملليمكافئ أدى إلى نقص الكالسيوم الكلى فى الثمار بما يعادل ٩.٢١ % مقارنة بـ ١٠.٠ ملليمكافئ .
- اضافة الكالسيوم بعد التزهير بمعدل ٥.٠ ملليمكافئ /لتر حققت أعلى مستوى من الكالسيوم الكلى فى الثمار (٤٤٤٩.٦ و ٣٨٩٥.٥ جزء فى المليون للموسم الأول والثانى)
- ٥.٠ ملليمكافئ كالسيوم حققت أعلى قيمة للكالسيوم المستخلص بالإيثانول فى كلا الموسمين (١٥٥.٢ و ١٦٩.٤ جزء فى المليون للموسم الأول والثانى على الترتيب) وزيادة مستوى الكالسيوم المضاف أعلى من ذلك أدى إلى نقص الكالسيوم المستخلص بالإيثانول معنويا فى كلا الموسمين .
- بالرغم من زيادة الكالسيوم المستخلص بالماء معنويا بغضافة الكالسيوم بمعدل ٥.٠ ملليمكافئ/لتر ، وجد نقص معنوى بزيادة مستوى الكالسيوم عن هذا الحد تحت ظروف التجربة .
- الكالسيوم المستخلص بكلوريد الصوديوم (الموجود فى صورة بكتات الكالسيوم) زاد زيادة كبيرة بزيادة الكالسيوم فى الحلول المغذى من ٠.٠ إلى٥.٠ ملليمكافئ / لتر
- اضافة الكالسيوم بمعدل ٥.٠ ملليمكافئ / لتر سببت أقصى زيادة فى الكالسيوم المستخلص بكلوريد الصوديوم (٣٤٤٠ و ٢٨٨٤ جزء فى المليون للموسم الأول والثانى على الترتيب) والذى يمثل الجزء الأكبر لصور الكالسيوم الموجودة فى الثمار
- الكالسيوم المستخلص بحمض الخليك والذى يمثل الكالسيوم الموجود فى صورة فوسفات وكربونات الكالسيوم زاد زيادة كبيرة بزيادة الكالسيوم فى المحلول المغذى من ٠.٠ إلى ٥.٠ ملليمكافئ /لتر ثم انتابت هذه الصورة حالة من الثبات بزيادة مستوى الكاليوم فى المحلول المغذى عن ذلك حت أقصى معدل مستخدم .
- فروق قليلة ولكن معنوية فى محتوى ثمار الطماطم من اوكسالات الكالسيوم بزيادة محتوى المحلول المغذى من الكالسيوم من ٥.٠ إلى ٢٠.٠ ملليمكافئ وهذه الزيادات تقدر بعشر قيمة الزيادات الحادثة عند زيادة محتوى المحلول المغذى من ٠.٠ إلى ٥.٠ ملليمكافئ / لتر .
- لوحظ أن أكبر معدل زيادة قد حدث فى الكالسيوم المستخلص بحمض الهيدروكلوريك نتيجة لإضافة الكالسيوم إلى المحلول المغذى مقارنة بالصور الأخرى للكالسيوم . وأن هذه الصورة للكالسيوم والتى تمثل الكالسيوم الموجود فى صورة سيليكات الكالسيوم محتوى ثمار الطماطم منها لم يختلف معنويا بين المعاملات ٥٤.٠ و ١٠.٠ ملليمكافئ / لتر . والمعاملة ٢٠.٠ ملليمكطافئ /لتر أدت إلى نقص معنوى فى هذه الصور مقارنة بمعاملة ٥.٠ ملليمكافئ /لتر .
- إضافة الكالسيوم بعد التزهير شجعت امتصاص النيتروجين والتى انعكست على محتوى ثمار الطماطم منه فى كلا الموسمين . حيث زاد محتوى ثمار الطماطم منه بما يعادل ٣.١٩ % فى الموسم الأول و ٣.٠٨ % فى الموسم الثانى . وحققت أيضا نفس المعاملة أعلى محتوى فوسفورى لثمار الطماطم (٠.٤٣٦ و ٠.٤٢٧ % فى الموسم الأول والثانى على الترتيب) .
- موعد اضافة الكالسيوم لم تؤثر معنويا على محتوى ثمار الطماطم من البوتاسيوم ولكن اضافته قبل التزهير زادت محتوى الثمار من الماغنسيوم بما يعادل ٢٨.٩ % ومن الصوديوم بما يعادل ٧.٣٥ % .

- تغيرات بسيطة فى المحتوى النيتروجينى لثمار الطماطم نتيجة زيادة مستوى الكالسيوم فى المحلول المغذى ، حيث تراوح المحتوى النيتروجينى للثما ر بين ٣.١٦ إلى ٣.٢٥٦ % فى الموسم الأول و بين ٣.٢٨ و ٣.٣٩ % فى الموسم الثانى .
- ٢.٠٥ و ٢.٠٩ % نقص فى محتوى ثمار الطماطم من الفوسفور نتيجة لزيادة محتوى المحلول المغذى من ١٠.٠ إلى ٢٠.٠ ملليمكافئ كاسيوم ، وذلك فى الموسم الأول والثانى على الترتيب .
- فى كلا الموسمين ٢٠.٠ ملليمكافئ كالسيوم فى المحلول المغذى أدت إلى نقص المحتوى البوتاسى للثمار (٢.٤٤ % نقص فى الموسم الأول و ٣.٦٩ % نقص فى الموسم الثانى).
- نقص محتوى ثمار الطماطم من الماغنسيوم بزيادة الكالسيوم فى المحلول المغذى وإن لم يكن هناك اتجاه ثابت لذلك النقص مع زيادة الكالسيوم فى المحلول المغذى .
- جدير بالذكر أن المعاملة التى تضمنت اضافة الكالسيوم قبل التزهير بمعدل ١٠.٠ ملليمكافئ / لتر سجلت أعلى محتوى لثمار الطماطم من الماغنسيوم (٥٢٨ و ٥٣٨ جزء فى المليون للموسم الأول والثانى على الترتيب).
- أقل محتوى لثمار الطماطم من الصوديوم تحقق فى حالة عدم اضافة كالسيوم للمحلول المغذى ، ،اعلى قيم للصوديوم فى ثمار الطماطم (١٧٨ و ١٧٣ جزء فى المليون للموسم الأول والثانى على الترتيب) تم الحصول عليها مع المعاملة التة تضمنت اضافى الكالسيوم للمحلول المغذى بمعدل ٥.٠ ملليمكافئ / لتر .
- المحتوى الصوديومى كمتوسط للمعاملات ١٠.٠ و ٢٠.٠ ملليمكافئ / لتر كالسيوم كان أقل من المحتوى الصوديومى كمتوسط للمعاملة التى يحتوى المحلول المغذى فيها على ٥.٠ ملليمكافئ / لتر وذلك بما يعادل ١٧.٤٢ و ٢٨.٦٥ % فى الموسم الأول وبما يعادل ١٧.٦٣ و ٢٨.٩ % فى الموسم الثانى .

قام بتحكيم البحث

أ.د / السيد محمود الحديدى — كلية الزراعة – جامعة المنصورة

أ.د / عادل محمد يوسف أبو الخير — كلية الزراعة – جامعة كفر الشيخ

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