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EFFECT OF CALCIUM SPRAY ON GROWTH, YIELD, BLOSSOM-END ROT OCCURRENCE AND STORABILITY OF TOMATOES UNDER CALCAREOUS SOIL CONDITIONS IN DELTA OF EL-ARISH VALLEY

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ABSTRACT

Present study was carried out during 2011 and 2012 seasons at the Experimental Farm, Fac. Environ. Agric. Sci., El-Arish, North Sinai, Egypt, to study the effect of calcium foliar spray frequency in form of Ca-chelate (1.5 g/l) and $CaCl_2$ (1.5 g/l) on growth, yield blossom end rot (BER), and shelf life of tomato fruits. The experiment included seven treatments; *i.e.*, spraying with tap water (T1) as control, Ca-chelate foliar spray every five days (T2), Ca-chelate foliar spray every 10 days (T3), Ca-chelate foliar spray every 15 days (T4), $CaCl_2$ foliar spray every five days (T5), $CaCl_2$ foliar spray every 10 days (T6) and $CaCl_2$ foliar spray every 15 days (T7). Tomato transplants (*Lycopersicon esculentum* Mill.) *cv.* "GS-12" were transplanted on May 12^{th} in both seasons. The highest number of leaves, clusters and flowers per plant were achieved with T7. The largest leaf area per plant and the highest total and marketable yield per faddan for both growing seasons were accounted with T4. BER % significantly affected by both calcium sources at different frequencies. Both TSS and vitamin-C at zero time and after storage fruits for 14 days were significantly affected by Ca treatments. Brightness (L*), hue angle (color angle) were declined and C* values seems stable or have little tendency to increase after 14 days storage period in tomato fruits. Color a* and lycopene were increased after 14 days from storage. The preharvest calcium treated tomato fruits were higher in lycopene content in fresh and stored fruits than control (T1).

Key words: Tomato, calucium, foliar spray, growth, yield, blossom end rot, storability.

INTRODUCTION

Agriculture in North Sinai is depending mainly on well water, the over consumption of well water and poor feeding of rainfall caused a gradual increase in water salinity, high water salinity and sandy or calcareous soils caused a hard stress on vegetable plants. So the careful selection among vegetable crops and the use of inexpensive methods to decrease the effect of high salinity and mineral precipitation are very important. Addition of calcium as foliar spray on tomato plants is important to avoid precipitation essentially under calcareous and saline conditions. It has been shown that exogenous application of Ca^{2+} can improve plant growth under environmental stress. Besides, the function of calcium is clearly reflected by stabilization of the middle lamella as calcium pectate for strengthening the cell walls and plant tissue (Marschner, 1993; Barrett *et al.*, 1998).

Blossom-end rot (BER) is attributed to an inadequate supply of Ca^{2+} to the fruits and it is, therefore called a calcium-related disorder (Shear, 1975). It may cause severe economic losses in tomato fruits. Saure (2001) found a correlation between the occurrence of BER and Ca^{2+} nutrition. Other researchers argued that BER might not be directly related to Ca deficiency. Nonami *et al.* (1995) supported their view by the fact that there are discrepancies in reported values for Ca in fruits with and without BER. Generally, any factors that increase fruit Ca demand and reduce Ca transport to fruit would increase the incidence of BER (Ho *et al.*,

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1999). Calcium deficiency in tomato reduces leaf size, and causes necrosis of young leaves (Adams and Holder, 1992).

Exogenous application of Ca^{2+} can improve plant growth under environmental stress (Marschner, 1993; Tuna *et al.*, 2007). Calcium application increased growth, number of fruits per plant, fruit yield, vitamin-C, TSS and nutrient contents of tomato fruits (Rady, 2012), reduced the incidence of BER and decreased total marketable yield (Hao *et al.*, 2000). Rady (2012) found that the increase in calcium rates caused positive gradual increase in tomato growth, chlorophyll content, number of fruits per plant and fruit yield.

Jamal and Kubota (2006) showed that, no significant changes in TSS both in room and low temperatures stored tomato fruits. In addition pH and TSS were increased, while vitamin-C was decreased with prolonging storage period (Ramana *et al.*, 1979; Dhruba and Durga, 2006; Moneruzzaman *et al.,* 2008). Calcium chloride is acidic in nature, it might has lowered the pH of the treated fruits (Njoroge and Kerbel, 1993; Dhruba and Durga, 2006).

The changes in chemical compositions behavior after storage were reported by Salunkhe *et al.* (1991). Storage under high temperature caused lowering in vitamin-C (Yeshida *et al.*, 1984). Calcium improved the Ca^{+2} and ascorbic acid contents in tomato fruits (Subbiah and Perumal, 1990; Gracia *et al.*, 1996; Sammi and Masud, 2007).

The highest Ca (%) in tomato fruits produced from spraying tomato plants with Ca-chelate every five days, while the lowest one was found at control treatment (Lopez and Satti, 1996).

Guill′en *et al.* (2006) found that color and firmness of tomato fruits have rapid changes during postharvest storage and responsible for its reduced shelf life. Calcium might delayed senescence (Sharma *et al.,* 1996). However, the presence of high levels of Ca in the fruit negatively affected the firmness and shelf life of tomato and delay aging or ripening (Grant *et al.*1973; Stanly *et al.*, 1995; Ho *et al.*, 1999; Sammi and Masud, 2007). Storage duration and temperature have significant effects on weight loss (Kumar *et al.*, 1999; Jamal and Kubota, 2006).

Tomatoes red color indicate that lycopene content varies among cultivars, stage of maturity and growing conditions (Sahlin *et al.*, 2004). It increased during storing tomato at room temperature (Jamal and Kubota, 2006). Calcium chloride was important for increasing lycopene content (Subbiah and Perumal, 1990). Audrius *et al.* (2008) reported that human identification of colors is quite complex where sensations like brightness, intensity, lightness and others modify the perception of the primary colors (red, blue, yellow) and during tomato ripening their color lightness L* and the ratio of white and black colors decreased, the hue angle had a tendency to decline, the color index a* showed the most obvious change.

The color of the fruits is an important property for customers. Lycopene gives the deep red color of ripe tomatoes. The biosynthesis of pigments is under genetic control. The a*, b* and a*/b* parameters are plotted against maturity stages. The a* values in the mature green stage ranged between −10 and −2, and in the breaker stage between −2 to +7. After this stage, the a* values increased rapidly until the pink maturity stage.

The a* values in the red and deep red stage ranged between 23 and 29. In the case of tomato fruits the b* values never decreased naturally below zero and varied in a narrow range between 20 and 30. The trend line of a*/b* was very similar to the trend line of a*. The values of the ratio increased continuously. The higher the lycopene content was the higher of a*/b* ratio. Hence it could be concluded that the color indicates the lycopene content (Brandt *et al.*, 2006).

The lycopene content determined from the color of the fruit according to D'Souza *et al.* (1992) reflect the best correlation (R^2 = 0.83) between lycopene and color was with the $(a^*/b^*)^2$ factor.

This work aimed to study firstly, the effect of calcium in form of Ca-chelate and $CaCl_2$ foliar spray on growth, yield, quality and storability of tomato fruits. Secondly, surmount of blossom-end rot (BER) physiological disorder under calcareous soils.

MATERIALS AND METHODS

Two field experiments were carried out during the summer seasons of 2011 and 2012 at the experimental Farm, Fac. Environ. Agric. Sci., El-Arish, North Sinai, Egypt. This experiment included seven treatments which were: spraying with tap water as control treatment (T1), Ca-chelate at a rate of 1.5 g/l was sprayed on tomato plants every 5 days (T2), every 10 days (T3), and every 15 days (T4); also, $CaCl_2$ at the rate of 1.5 g/l was sprayed every 5 days (T5), every 10 days (T6) and every 15 days (T7). Treatments were randomly arranged in a RCBD with three replications. Tomato plants of all treatments received 15, 10 and 5 sprays during the growing seasons every 5, 10, 15 days, respectively. Foliar spray treatments started at 10 days after transplanting. Tomato transplants (*Lycopersicon esculentum* Mill.) cv. "GS-12" were transplanted on May 12th in both seasons at 50 cm distance between plants along the dripper line and 0.9 m between each two dripper lines. Plot area was 37.5 m^2 (25 m length and 1.50 m width). Each experimental unit recived equal amount of FYM at a rate of 30m^3/fad. Fertigation through drip irrigation system was used to add chemical fertilizers after transplanting (parallel with plant growth, two times a week). Standard grower production practices for nutrients, irrigation, pest and weed control of growing tomato in the reigone of the experiment were followed in this destrict. Soil physical and chemical properties and chemical analysis of irrigation water are given in Table 1.

Data Recorded

Vegetative Growth and Flowering Measurements

At full bloom stage, samples of three plants were randomly taken and the following data were recorded: stem length (cm), number of branches, number of leaves, leaf area, number of clusters and number of flowers per plant.

Yield and its Components

At maturity stage (30-60% of fruit surface red or pink) allover fruits of each plot were counted and weighed allover the harvesting period and the following data were recorded: BER%, number of fruits per plant, average fruit weight (g), marketable yield and total yield ton/faddan.

Storage Treatments

Sample of fruits from each experimental plot of the second harvest were randomly taken and were directly transported to the lab for washing and arranged in Styrofoam trays (60 fruits for each treatment) in three replicates (20 fruits/ replicate).

Fruits of different treatments were placed at room temperature (average of 29.3, 29°C and 63, 65% RH, in 2011 and 2012 seasons, respectively) for 14 days; physical and chemical parameters were measured in tomato fruits before storage at zero time and after 14 days storage period.

Chemical Parameters

The following chemical parameters were measured in fruits juice obtained by blending a sample of fruit flesh from each experimental treatment: total soluble solids (TSS), pH. and vitamin-C. Also, Ca% in tomato fruit tissues as dry weight basis was determined. All studied fruit chemical analyses were measured according to AOAC. (1975).

Physical Measurements

The following physical parameters were measured in tomato fruits before storage at zero time and after 14 days storage period; *i.e.,* weight loss (%) for stored fruits, fruit firmness, lycopene content according to the formula of D'Souza *et al.* (1992). Color assessment by image processing program: The images of the samples were taken from above about 0.8 m from the samples; each sample (replicate) minimally included six fruits in three replicates for each treatment. The average red (R), green (G) and blue (B) color components of the area chosen were calculated by the computer program. The color of the sample was characterized by this RGB values or by a* and b* values of the CIE L*a*b* color index calculated according to Trupple and Herold (1996).

L* (Lightness): the sensation of an area's brightness relative to a reference white.

L* Scales from 0 to 100 (0= dark, 100= light).

C* (Chroma): the colorfulness of an area relative to the brightness of the reference white.

$C^* = (a^{*2} + b^{*2})^{0.5}$ Hue angle = $\tan^{-1} b^*/a^*$ hue°, we can get the angle of the color by using a* and b* values on axis (Fig. 1).

Table 1. Initial of some physical and chemical properties of investigated soil profile of cultivated area and irrigation water

Properties	Season 2011	Season 2012
Soil properties		
Soil texture class	**Loamy sand**	**Loamy sand**
Soil chemical properties		
EC (dS m^{-1}) in (1:5) soil water extract)	1.32	1.45
Cl^- (meq/l)	5.36	6.48
pH in (1:2.5) soil water suspension extract)	8.2	8.00
Organic matter (%)	0.170	0.180
$CaCO_3$ (%)	16.21	15.56
Total N (ppm)	15.31	14.88
Total P (ppm)	46.11	44.17
Total K (ppm)	92.88	94.15
Chemical analyses of irrigation water		
EC (dS m^{-1})	6.12	6.74
pH	7.59	7.64
Cl- (meq/l)	47.04	48.46

Soil and water were analyzed according Richards (1954) and Jackson (1967).

- Soil sample was taken from 30 cm depth of soil surface.

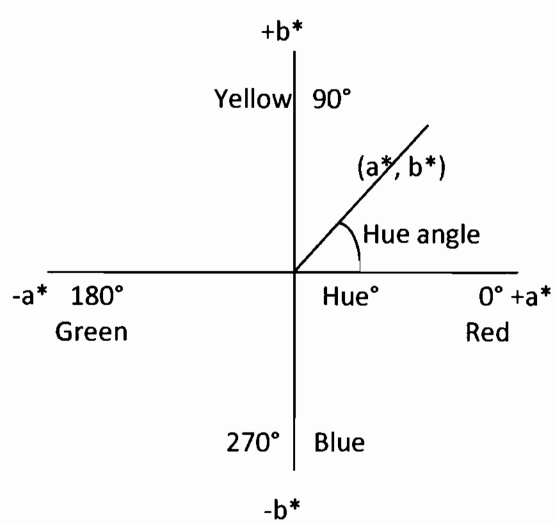


Fig. 1. a* and b* are colors: On the horizontal axis, positive a* indicates a hue of red, negative a* green. On the vertical axis, positive b* indicates yellow and negative b* blue

Statistical Analysis

Data were analyzed using the "MSTATC" computer software package. Analysis of variance was first conducted. If the treatment effects were significant, then their means were separated with Duncan's multiple-range test (Duncan, 1958).

RESULTS AND DISCUSSION

Vegetative Growth and Flowering Traits

Data in Table 2 show the effect of calcium foliar spray on tomato vegetative characters and flowering. No significant differences were observed on stem length and number of branches per plant, while numbers of leaves per plant and leaf area/plant (cm^2) were significantly affected. T7 accounted the highest number of leaves, number of clusters and number of flowers per plant while, T4 accounted the largest leaf area per plant for both growing seasons.

It is also clear from such data that Ca treatments affected positively number of clusters and number of flowers per plant. These results were in harmony with the findings of Jones (1999) who found that Ca enhanced pollen germination and growth. Also, it activated number of enzymes for cell mitosis division and elongation and this in turn increased tomato plant growth.

Calcium deficiency in tomato reduced leaf size (Adams and Holder, 1992). Spraying Ca-chelate every 15 days (T4) gave the largest leaf area/plant, being 3.0% higher than control (average of two seasons), but spraying every 5 days (T2) gave the smallest leaf area/plant (8.8%) lower than the control (average of two seasons). The reduction in leaf area/plant in (T2) in the two seasons (Table 2) may be attributed to the effect of salt accumulation as a result of spraying every 5 days, which affected negatively leaf area/plant. These results are in harmony with the findings of Adams and Holder (1992), Lopez and Satti (1996) and Caines and Shennan (1999). Increasing calcium rates caused positive gradual increase in tomato growth (Rady, 2012); wherein exogenous application of Ca^{2+} improved plant growth under environmental stress (Marschner, 1993).

Chlorine plays an important role in the light reaction of plant photosynthesis (Stelezer *et al.*, 1975). Decreasing the period among spraying timese especially $CaCl_2$ treatment caused a decrease in both leaves number and area/plant, this results may be refer to the effect of Cl^- toxicity that appear with weakness and reduction in foliar size and also to its toxicity symptoms which appear more severe under drought stress (Srivastava and Gupta, 1996); they added that leaves are active in mineral absorption because of their higher surface area. In the present study both chlorine and salinity increase the stress and chlorine accumulation; this case was illustrated by Stelezer *et al.* (1975) who reported that plants grown in saline-alkali soils may accumulate even more than 1 per cent Cl^- in their tissues and the normal concentration in plant tissues must be not more than 0.2%.

Yield and its Components

Data in Table 3 clear significant effects of Ca-chelate and $CaCl_2$ on tomato yield and its components during both growing seasons. Foliar spray of tomato plants with Ca-chelate sprayed every 10 days (T4) recorded the highest total and marketable yield per faddan. Both calcium sources at different frequences affected significantly BER %. Spraying plants with Ca-chelate (T2, T3 and T4) gave fruits with low percentage of BER, and the lowest one was found with (T2) treatment during both seasons. The control treatment and spraying with $CaCl_2$ (T5, T6 and T7) resulted in the highest BER%. While, spraying tomato plants with $CaCl_2$ every 15 days (T7) resulted in the highest number of fruits and the lowest average fruit weight per plant in both growing seasons.

The high obtained total and marketable yield with T4 may be refer to the largest leaf area/ plant (Table 3), while the highest values of average fruit weight may be refer to the highest leaf area available for each fruit. Regarding average fruit weight, it is clear that, T3 gave the highest fruit weight, while T7 recorded the lowest one. These results are logic because of dividing the leaf area per plant (Table 2)/ number of fruits per plant (Table 3), clearly we can give the largest leaf area/plant (150.1 and 160.5 cm^2/fruit), which produced fruit weight of 72.7 and 75.7 g/fruit for the 1st and 2nd seasons,

Table 2. Effect of spray with Ca-chelate and $CaCl_2$ and their spray frequencies on vegetative growth characters and flowering of tomato plants at full bloom stage during 2011 and 2012 seasons

Treat.	Stem length (cm)	No. branches /plant	No. leaves/plant	Leaf area/ plant (cm^2)	No. clusters /plant	No. flowers /plant
			2011 Season			
T1	48.3 a	8.2 a	76.0 d	5027 ab	31.0 c	122.5 c
T2	46.8 a	8.5 a	93.7 b	4511 c	32.0 c	117.2 c
T3	48.0 a	8.5 a	74.2 d	4923 abc	32.5 c	123.7 c
T4	49.8 a	8.5 a	80.2 cd	5299 a	37.2 b	144.3 b
T5	48.5 a	9.7 a	85.3 c	4686 bc	38.3 b	129.0 bc
T6	49.8 a	8.3 a	85.8 c	4836 bc	39.5 b	141.3 b
T7	49.3 a	8.2 a	104.2 a	4908 abc	47.8 a	179.7 a
			2012 Season			
T1	51.3 a	8.9 a	80.0 d	5117 bc	32.8 c	133.5 d
T2	52.6 a	9.4 a	96.2 b	4742 d	34.8 c	126.2 d
T3	51.8 a	9.5 a	79.2 d	5217 b	33.7 c	136.7 d
T4	55.6 a	9.5 a	86.0 c	5546 a	40.4 b	157.3 b
T5	52.3 a	10.1 a	91.3 bc	4632 d	40.1 b	140.0 cd
T6	52.6 a	9.0 a	91.6 bc	5031 c	41.2 b	154.3 bc
T7	51.8 a	8.9 a	108.2 a	5004 c	49.6 a	190.7 a

Means followed by the same letter (s) in a column within treatment group are not significantly different at P=0.05 according to Duncan's multiple range test.

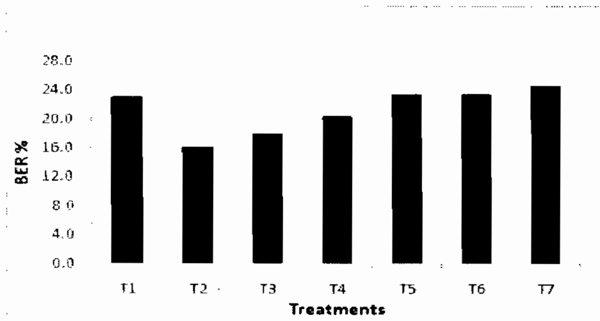
T1 water spray (control), T2 Ca-chelate foliar spray (every 5 days), T3 Ca-chelate foliar spray (every 10 days), T4 Ca-chelate foliar spray (every 15 days), T5 $CaCl_2$ foliar spray (every 5 days), T6 $CaCl_2$ foliar spray (every 10 days) and T7 $CaCl_2$ foliar spray (every 15 days).

Table 3. Effect of spray with Ca-chelate and $CaCl_2$ and their spray frequencies on tomato yield and its components during 2011 and 2012 seasons

Treat.	No. fruits /plant	Average fruit weight (g)	Marketable yield ton/fad.	Total yield ton/fad.	BER %
			2011 Season		
T1	38.1 b	62.2 bc	12.52 ab	16.21 ab	22.9 ab
T2	32.1 c	63.8 bc	10.75 cd	12.87 c	16.5 c
T3	32.8 c	72.7 a	12.56 ab	15.20 b	17.3 c
T4	39.1 b	65.1 ab	13.44 a	17.05 a	20.9 b
T5	36.8 b	52.2 de	10.13 d	13.21 c	23.4 ab
T6	40.4 b	56.2 cd	11.97 bc	15.63 ab	23.6 ab
T7	46.6 a	47.0 e	11.56 bc	15.43 ab	24.8 a
			2012 Season		
T1	39.5 bc	63.3 b	13.19 b	16.92 a	22.0 ab
T2	31.9 d	68.0 b	11.42 d	13.52 c	15.5 d
T3	32.5 d	75.7 a	12.99 b	15.91 b	18.3 cd
T4	41.4 b	64.6 b	14.15 a	17.63 a	19.5 bc
T5	37.4 c	52.4 cd	10.35 e	13.42 c	22.9 ab
T6	41.7 b	55.9 c	12.30 c	15.94 b	22.8 ab
T7	47.0 a	48.3 d	11.97 c	15.82 b	24.2 a

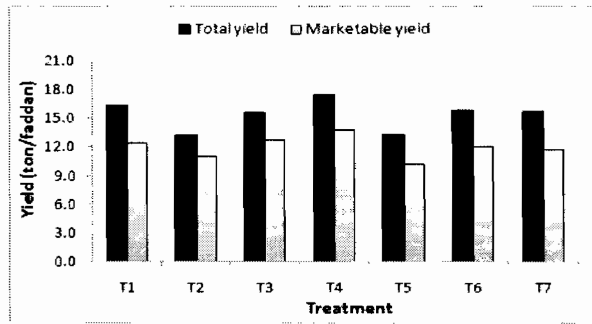
Means followed by the same letter (s) in a column within treatment group are not significantly different at P=0.05 according to Duncan's multiple range test.

T1 water spray (control), T2 Ca-chelate foliar spray (every 5 days), T3 Ca-chelate foliar spray (every 10 days), T4 Ca-chelate foliar spray (every 15 days), T5 $CaCl_2$ foliar spray (every 5 days), T6 $CaCl_2$ foliar spray (every 10 days) and T7 $CaCl_2$ foliar spray (every 15 days).



T1 water spray (control),
T2 Ca-chelate foliar spray (every 5 days),
T3 Ca-chelate foliar spray (every 10 days),
T4 Ca-chelate foliar spray (every 15 days),
T5 $CaCl_2$ foliar spray (every 5 days),
T6 $CaCl_2$ foliar spray (every 10 days) and
T7 $CaCl_2$ foliar spray (every 15 days).

Fig. 2. Effect of calcium sources and spray frequency on BER % of tomato fruits (average of two seasons)



T1 water spray (control),
T2 Ca-chelate foliar spray (every 5 days),
T3 Ca-chelate foliar spray (every 10 days),
T4 Ca-chelate foliar spray (every 15 days),
T5 $CaCl_2$ foliar spray (every 5 days),
T6 $CaCl_2$ foliar spray (every 10 days) and
T7 $CaCl_2$ foliar spray (every 15 days).

Fig. 3. Effect of calcium sources and spray frequency on total and marketable yields of tomato fruits (average of two seasons)

respectively. The lowest leaf area/plant (105.3 and 106.4 cm^2/ fruit) produced the lowest fruit weight at T7 (47.0 and 48.3 g/fruit for the 1st and 2nd seasons, respectively). Rady (2012) found that increasing calcium rates caused positive gradual increase in tomato growth, chlorophyll content, number of fruits per plant and fruit yield. Similar results regarding reduction in BER incidence by spraying tomato plants with 0.1 M of $CaCl_2$ biweekly were reported by (Hao *et al.*, 2000). Bar-Tal and Pressman (1996), observed a decrease in total marketable yield with increasing Ca levels.

According to Bar-Tal and Pressman (1996) and Hao and Papadopulos (2003) the highest Ca concentrations in the nutrient solution allow for higher total and marketable fruit yields, larger fruits and higher percentage of marketable fruit compared to low Ca concentrations.

It is clear from the data that spraying tomato plants with Ca-chelat every 5 days resulted in the lowest percent of BER, this result may be due to the fact that there was a negative correlation between the occurrence of BER and Ca^{2+} nutrition and Ca deficiency as the primary cause of BER has been derived from observations that affected fruits by BER always have a lower Ca content compared to healthy fruits (Ho *et al.*, 1999; Saure, 2001). Indeed, most modern textbooks and technical papers hold that Ca^{2+} deficiency is the primary cause of BER.

The low yield achieved from spraying $CaCl_2$ (T2 and T5) compared to control treatment may be refer to Cl toxicity, which negatively affected plant growth and this in turn reduces the yield (Srivastava and Gupta, 1996).

Chemical Analysis for Fresh and Stored Fruits

Data in Table 4 show significant differences in TSS of fresh tomato fruits obtained from Ca treated plants, where spraying tomato plants with $CaCl_2$ produced higher TSS than other treatments in both growing seasons. After 14 days from storage TSS increased in both growing seasons. Data show also that significant differences in pH were recorded among treatments in the first season.

Regarding vitamin-C, data in Table 4 show that vitamin-C was significantly affected by Ca treatments in both fresh and stored fruits in both seasons. It is clear that, after 14 days from storage, vitamin-C tended to decrease in tomato fruits (Table 4). These results are in harmony with the findings of Sammi and Masud (2007).

The increase in leaves surface area increased mineral absorption (Srivastava and Gupta, 1996). In the case of fresh fruits, Ca treated tomato had higher TSS than control. The increase in TSS as a result of $CaCl_2$ spray may be refer to the effect of Cl stress, which lead to higher fruit quality; *i.e.* TSS and vitamin-C. This

Table 4. Effect of spray with Ca-chelate and $CaCl_2$ and their spray frequencies on fruit chemical characters of fresh fruit (zero time) and after 14days storage of tomato fruits during 2011 and 2012 seasons

Treat.	Fresh fruits (zero time)			Tomato fruits after 14 days storage period		
	TSS (%)	pH	Vit. C (mg/100g)	TSS (%)	pH	Vit. C (mg/100g)
				2011 Season		
T1	6.2 b	3.99 a	17.50 ab	7.6 b	3.94 d	16.03 a
T2	6.4 b	3.91 c	17.50 ab	7.7 b	3.92 f	16.03 a
T3	6.3 b	3.91 c	17.00 bc	7.2 d	3.93 e	15.03 ab
T4	6.4 b	3.89 d	16.77 bc	7.5 c	3.88 g	14.03 b
T5	6.7 a	3.88 e	18.50 a	7.9 a	3.95 c	15.03 ab
T6	6.7 a	3.96 b	17.00 bc	6.8 e	3.97 a	14.87 ab
T7	6.6 a	3.96 b	16.00 c	6.7 f	3.96 b	14.03 b
				2012 Season		
T1	6.0 c	3.83 a	16.77 ab	7.7 ab	3.77 a	15.93 a
T2	6.2 bc	3.71 a	16.87 ab	7.6 ab	3.78 a	15.97 a
T3	6.1 c	3.74 a	16.37 bc	7.1 cd	3.83 a	14.97 ab
T4	6.2 bc	3.69 a	16.23 bc	7.4 bc	3.71 a	14.07 b
T5	6.6 a	3.58 a	17.90 a	7.9 a	3.81 a	14.90 ab
T6	6.5 a	3.82 a	16.77 ab	6.8 de	3.83 a	14.73 b
T7	6.4 ab	3.79 a	15.30 c	6.6 e	3.82 a	13.97 b

Means followed by the same letter (s) in a column within treatment group are not significantly different at P=0.05 according to Duncan's multiple range test.
T1 water spray (control), T2 Ca-chelate foliar spray (every 5 days),
T3 Ca-chelate foliar spray (every 10 days), T4 Ca-chelate foliar spray (every 15 days),
T5 $CaCl_2$ foliar spray (every 5 days), T6 $CaCl_2$ foliar spray (every 10 days) and
T7 $CaCl_2$ foliar spray (every 15 days).

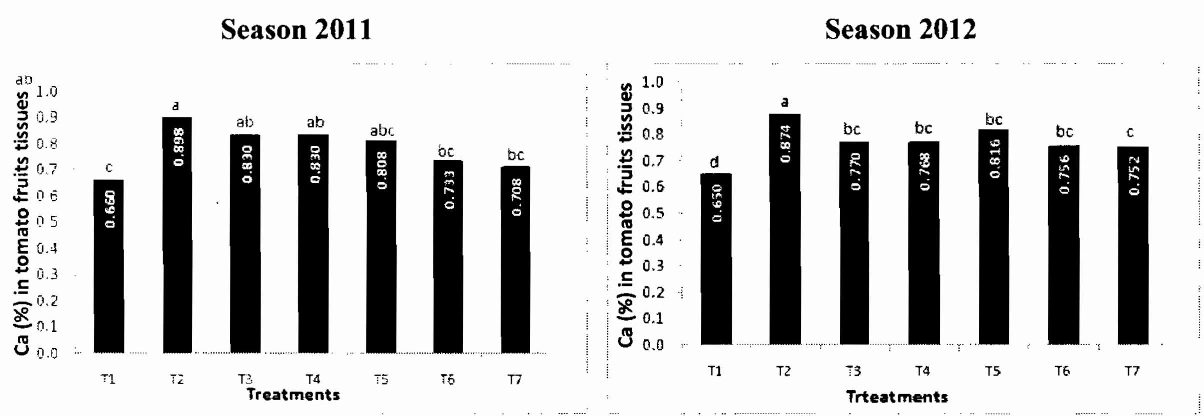
result was supported by Rady (2012) who found that increasing calcium rates caused positive gradual increase in tomato vitamin-C and TSS.

After storage, TSS values were increased in fruits, Moneruzzaman *et al.* (2008) reported that the percentage of pH and TSS were found to increase with gradual advancement in storage period. Cheour *et al.* (1990) came to similar results.

Nirupama *et al.* (2010) reported that $CaCl_2$ caused an increase in ascorbic acid content in tomato fruits which consider as indicator for the fruit is still in the ripening stage, while a decrease in vitamin-C indicates a senescent fruit (Esteves *et al.*, 1984). Earlier investigators, for example, Yeshida *et al.* (1984) and Moneruzzaman *et al.* (2008) indicated that high storage temperature increases enzymatic catalysis and leads to biochemical breakdown of compounds; *i.e.*, increasing TSS and lowering in vitamin-C after storage (Table 4) which could also partly be the cause for results in this study.

Sammi and Masud (2007) reviewed that calcium chloride reduced postharvest decay, controlled development of physiological disorders, improved quality and delayed aging or ripening (Grant *et al.*1973 and Stanly *et al.*, 1995). It improves the skin strength (Mignani *et al.*,1995). While, controlling ripening, softening, storage breakdown, rotting and decay at the same time (Conway and Sams, 1984; Sams *et al.* 1993; Izumi and Watada, 1994; Hong and Lee, 1999). It improved the Ca^{+2} contents, lycopene contents, ascorbic acid contents, firmness index (Subbiah and Perumal, 1990; Gracia *et al.*, 1996).

As for Ca% in tomato fruits tissues, data in Fig. 4 reflect significant differences among treatments. The highest Ca concentration was recorded in fruits obtained from tomato plants sprayed with Ca-chelate every 5 days and the lowest one was found with control treatment (water spray, T1) in both growing seasons. The low Ca content in fruit tissue obtained from untreated plants may be owe much to the poor



Means followed by the same letter (s) in a column within treatment group are not significantly different at P=0.05 according to Duncan's multiple range test.

T1 water spray (control), T2 Ca-chelate foliar spray (every 5 days), T3 Ca-chelate foliar spray (every 10 days), T4 Ca-chelate foliar spray (every 15 days), T5 $CaCl_2$ foliar spray (every 5 days), T6 $CaCl_2$ foliar spray (every 10 days) and T7 $CaCl_2$ foliar spray (every 15 days).

Fig. 4. Effect of calcium sources and spray frequencies on Ca (%) in tomato fruits tissues during 2011 and 2012 seasons

supply of Ca^{2+} to fruits, which resulted in Ca deficiency in its tissues (Mengel and Kirkby, 2001). The optimum Ca content in higher plants, is, generally, about 0.5% (on dry weight basis). High Ca level tended to increase the Ca content of fruits and leaves (Paiva *et al.*, 1998; Bombiti, 2006; Tuna *et al.*, 2007). On the other hand, the values of Ca% in fruits that had BER or not; explained that BER might not be directly related to Ca deficiency (Nonami *et al.*, 1995). This finding was in harmony with the results of the present study.

Physical Parameters

Regarding fruit physical parameters, data in Table 5 clear significant differences in firmness in case of fresh fruits and weight loss (%) at 14 days stored tomato fruits in both growing seasons. Tomato fruits treated with Ca-chelate had higher firmness with T2, T3 and T4, while spraying $CaCl_2$ every 10 and 15 days (T6 and T7) reduced tomato firmness in both growing seasons. It is clear from the data that, after 14 days storage, fruit firmness was decreased in both growing seasons by about 22% (average of two seasons). The lowest weight loss percent after 14 days storage were obtained with T7 in both growing seasons.

Results in Table 5 clear that spraying Ca-chelate produced, in general, the highest fruit firmness in fresh case. Firmness can be improved by spraying calcium salts (Cooper and Bangerth, 1976; Garcia *et al.*, 1995; Bombiti, 2006). Calcium is considered as an important factor for the maintenance of cell membrane integrity and middle lamella structure and the regulation of ion transport (Hanson, 1984; Barrett *et al.*, 1998). Increasing calcium supply to plants increased tissue elasticity, rather than increasing tissue rigidity (Jamal and Kubota, 2006).

Weight loss was mainly affected by storage duration, storage temperature and treatment (Kumar *et al.*, 1999). Higher rate of transpiration in room temperature stored tomatoes could be the main cause for higher weight loss. Calcium delayed senescence and rate of respiration in tomato fruits (Sharma *et al.*, 1996). Agar and Kaska (1995) and Dhruba and Durga (2006) came to similar results as the storage period prolonged the TSS of the fruit increased. In addition, weight loss is mainly due to the water loss and that lead to higher concentration of sugars in fruits during storage.

Color Analysis and Lycopene Content

Table 6 show marked decline in brightness (L*) of tomato fruits after storage in all treatments. Audrius *et al.* (2008) reported that when carotenoids started to be synthesized, the L* value went down, indicating darkening in tomato red color occurred.

Table 5. Effect of spray with Ca-chelate and $CaCl_2$ and their spray frequencies on firmness and weight loss % of tomato fruits at zero time and after 14 days storage during 2011 and 2012 seasons

Treat.	Fresh (Zero time)	After 14 days storage	
	Firmness (kg/cm^2)	Firmness (kg/cm^2)	Weight loss (%)
		2011 Season	
T1	2.53 b	1.83 a	6.6 b
T2	2.90 a	1.80 a	8.9 a
T3	2.87 a	1.77 a	8.6 a
T4	2.87 a	1.87 a	6.4 b
T5	2.73 a	1.93 a	8.9 a
T6	2.10 c	1.93 a	7.1 ab
T7	2.13 c	1.80 a	5.9 b
		2012 Season	
T1	2.30 b	1.95 a	6.2 cd
T2	2.50 a	2.10 a	8.3 ab
T3	2.60 a	2.10 a	8.1 ab
T4	2.60 a	1.83 a	6.5 cd
T5	2.20 b	2.00 a	8.7 a
T6	2.00 c	1.83 a	6.9 bc
T7	2.00 c	1.83 a	5.1 d

Means followed by the same letter (s) in a column within treatment group are not significantly different at P=0.05 according to Duncan's multiple range test.
T1 water spray (control), T2 Ca-chelate foliar spray (every 5 days),
T3 Ca-chelate foliar spray (every 10 days), T4 Ca-chelate foliar spray (every 15 days),
T5 $CaCl_2$ foliar spray (every 5 days), T6 $CaCl_2$ foliar spray (every 10 days) and
T7 $CaCl_2$ foliar spray (every 15 days).

Table 6. Effect of spray with Ca-chelate and $CaCl_2$ and their spray frequencies on L*, C* and Hue° of tomato fruits at zero time and after 14 days storage during 2011 and 2012 seasons

Treat.	Fresh fruits (Zero time)			After 14 days storage		
	L*	C*	Hue	L*	C*	Hue
			2011 Season			
T1	66.0 a	47.5 abcd	67.0 a	50.2 a	51.2 a	24.4 a
T2	63.5 a	44.4 cd	60.3 a	49.7 a	50.1 ab	22.1 a
T3	62.1 a	49.3 abc	53.8 a	48.8 a	50.1 ab	21.9 a
T4	63.6 a	49.8 ab	62.1 a	49.4 a	49.2 b	24.2 a
T5	64.1 a	43.5 d	62.6 a	49.7 a	48.5 b	22.7 a
T6	62.6 a	51.8 a	55.4 a	48.9 a	48.6 b	23.4 a
T7	65.0 a	45.3 bcd	63.0 a	48.3 a	48.9 b	22.1 a
			2012 Season			
T1	66.3 a	46.4 bc	68.2 a	50.6 a	50.6 a	24.8 a
T2	65.3 ab	42.4 cd	66.3 a	49.5 a	50.4 a	19.8 b
T3	61.5 c	50.1 ab	52.0 b	50.1 a	48.2 a	20.8 b
T4	62.9 bc	49.2 ab	59.6 ab	50.2 a	48.5 a	22.4 ab
T5	64.9 ab	41.2 d	62.5 a	50.0 a	47.6 a	18.6 b
T6	60.4 c	53.8 a	50.9 b	49.9 a	47.5 a	20.3 b
T7	66.4 a	46.9 bc	68.5 a	50.0 a	47.8 a	20.1 b

Means followed by the same letter (s) in a column within treatment group are not significantly different at P=0.05 according to Duncan's multiple range test.
L* (Lightness): Scales from 0 to 100 (0= dark, 100= light)
C* (Chroma): the colorfulness of an area relative to the brightness of the reference white.
Hue angle = $\tan^{-1} b^*/a^*$ [the angle of the color by using a* and b* values on axis (Fig. 1)].
T1 water spray (control), T2 Ca-chelate foliar spray (every 5 days),
T3 Ca-chelate foliar spray (every 10 days), T4 Ca-chelate foliar spray (every 15 days),
T5 $CaCl_2$ foliar spray (every 5 days), T6 $CaCl_2$ foliar spray (every 10 days) and
T7 $CaCl_2$ foliar spray (every 15 days).

C* values seems stable or have little tendency to increase after storage. Hue° angle (color angle) clearly declined after storage. Audrius *et al.* (2008) obtained a similar trend of the present results, where during fruit ripening process, the hue° angle had a tendency to decline, particularly the hue° value was decreased between ripening stages.

Results of Table 6 show that preharvest calcium treatments affected positively fruit ripening according to Hue° values in case of fresh tomato and after 14 days storage of tomato fruits comparing to the control.

The initial step required for ensuring successful marketing is to harvest the crop at the optimum stage of maturity (Sammi and Masud, 2007). Lopez Camelo and Gomez (2004) reported that tomato fruit color is one of the most important and complex attributes of fruit quality. The complexity of tomato color is due to the presence of a diverse carotenoid pigment system, their appearance being conditioned by pigment types and concentrations, and subject to both genetic and environmental regulation. Audrius *et al.* (2008) reported that tomatoes were usually consumed at their maximum organoleptic quality which takes place when they reach the full red color stage but before excessive softening. This means that color in tomato is the most important external characteristic to assess ripeness and postharvest life and it is a major factor in the consumer's purchase decision.

Data in Table 7 and Fig. 5, show no significant differences among treatments for color a* values or lycopene content in both growing seasons, except for fresh fruits which were significantly affected by such treatments in the second season only.

Table 7. Effect of spray with Ca-chelate and $CaCl_2$ and their spray frequencies on color a* and lycopene content of tomato fruits at zero time and after 14 days of storage during 2011 and 2012 seasons

Treat.	Fresh fruits (Zero time)		After 14 days storage	
	a*	Lycopene (μg/g)	a*	Lycopene (μg/g)
		2011 Season		
T1	18.77 a	20.13 a	46.70 a	354.7 a
T2	22.17 a	33.23 a	46.47 a	452.2 a
T3	29.20 a	45.90 a	46.50 a	450.9 a
T4	23.40 a	25.93 a	44.90 a	362.1 a
T5	20.03 a	24.93 a	44.73 a	444.2 a
T6	29.33 a	40.53 a	44.53 a	403.7 a
T7	20.50 a	25.50 a	45.37 a	446.3 a
		2012 Season		
T1	17.30 d	17.43 b	45.87 a	348.3 a
T2	16.80 d	22.67 b	47.50 a	572.9 a
T3	30.80 ab	49.43 a	44.97 a	520.0 a
T4	25.00 bc	31.00 b	44.73 a	429.4 a
T5	19.03 cd	25.07 b	45.07 a	639.8 a
T6	33.90 a	52.70 a	44.53 a	543.9 a
T7	17.10 d	17.33 b	44.87 a	543.1 a

Means followed by the same letter (s) in a column within treatment group are not significantly different at P=0.05 according to Duncan's multiple range test.

a*; values on axis (Fig. 1), on the horizontal axis, positive a* indicates a hue of red, negative a* green.

T1 water spray (control), T2 Ca-chelate foliar spray (every 5 days), T3 Ca-chelate foliar spray (every 10 days), T4 Ca-chelate foliar spray (every 15 days), T5 $CaCl_2$ foliar spray (every 5 days), T6 $CaCl_2$ foliar spray (every 10 days) and T7 $CaCl_2$ foliar spray (every 15 days).

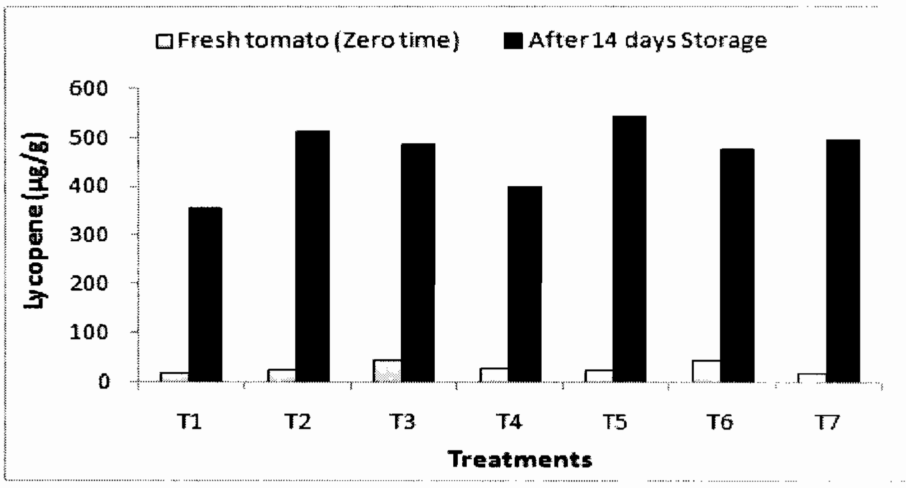


Fig. 5. Effect of calcium sources and spray frequencies at zero time and 14 days storage on lycopene concentration of tomato fruits

Generally, it is clear from the data in Table 7 that color a* and lycopene were increased after 14 days storage, color a* values increased during storage for all ripening stages (Guill´en *et al*., 2006). Also, it is clear that before and after storage period the tomato fruits obtained from preharvest calcium treatments were higher in lycopene content than control (T1). The increase in a* values and lycopene content refered to the progress in red color. Red color is the result of chlorophyll degradation as well as synthesis of lycopene and other carotenoids (Fraser *et al.*, 1994). The total lycopene content in tomatoes varies between 90 and 190 µg/g fresh weight (Baysal and Starmans, 2000), the high level of lycopene content in Table 7 may owe much to that it is considered a skin carotene; skin extracts contain high amounts of lycopene than other parts of tomato fruits (Sharma and Le Maguer, 1996). Also Sheetal and Ananthanarayan (2007) found that lycopene concentration is high in tomato peel and they found that the extraction of lycopene from tomato peel was about 450 µg/g, while it was different from those obtained by using whole tomatoes 70 µg/g.

REFERENCES

Adams, P. and R. Holder (1992). Effects of humidity, Ca and salinity on the accumulation of dry matter and Ca by the leaves and fruit of tomato (*Lycopersicon esculentum* Mill.). J. Hort. Sci., 67: 137-142.

Agar, T. and N. Kaska (1995). Effect of different harvest dates and post harvest treatments on the storage quality of mandarins. In: Proceedings of the international symposium on post harvest physiology, pathology and technologies for horticultural commodities: Recent Advances. Agadir, Morocco., 75-82.

AOAC. (1975). Official Methods of Analysis Chemists. 12th ed. AOAC. Washington D.C. USA.

Audrius, R., V. Pranas and B. Česlovas (2008). Quality and physiological parameters of tomato (*Lycopersicon esculentum* Mill.) fruits of lithuanian selection. Biologija, 54 (2): 108–111.

Barrett, D.M., E. Garcia and J.E. Wayne (1998). Textural modification of processing tomatoes. Crit. Rev. Food Sci. Nutr., 38: 173–258.

Bar-Tal, A. and E. Pressman (1996). Root restriction and potassium and calcium solution concentrations affect dry-matter production, cation uptake, and blossom-end rot in greenhouse tomato. J. Amer. Soc. Hort. Sci., 121 (4): 649- 655.

Baysal, T.E. and D.A.J. Starmans (2000). Supercritical CO_2 extraction of beta-carotene and lycopene from tomato paste waste. J. Agric. Food Chem., 48: 5507–5511.

Bombiti, N. (2006). Yield and quality of tomato as influenced by differential Ca, Mg and K nutrition. M.Sc. Thesis, Fac. Natural and Agric. Sci. Pretoria Univ. South Africa.

Brandt, S., Z. Pek, E. Barna, A. Lugasi and L. Helyes (2006). Lycopene content and color of ripening tomatoes as affected by environmental conditions. J. Sci. Food Agric., 86: 568–572.

Caines, A.M. and C. Shennan (1999). Interactive effects of Ca^{2+} and NaCl salinity on the growth of two tomato genotypes differing in Ca^{2+} use efficiency. Plant Physiol. Biochem., 37 (7/8): 569–576.

Cheour, F., C.J. Willemot, Y. Arul, J. Desjardins, P.M. Makhlouf and A. Gosselin (1990). Effects of foliar application of $CaCl_2$ on postharvest strawberry ripening. J. Am. Soc. Hort. Sci., 115:789-792.

Conway, W.S. and C.E. Sams (1984). Possible mechanism by which postharvest calcium treatment reduces decay in apples. Phytopathology, 74 (2): 208-210.

Cooper, T. and F. Bangerth (1976). The effect of Ca and Mg treatments on the physiology, chemical composition and bitter-pit development of 'Cox's Orange' apples. Scientia Horticulturae, 5 (1): 49-57.

D'Souza, M.C., S. Singha and M. Ingle (1992). Lycopene concentration of tomato fruit can be estimated from chromaticity values. Hort. Sci., 27: 465–466.

Dhruba, R.B. and M.G. Durga (2006). Effect of harvesting method and calcium on postharvest physiology of tomato. Nepal Agric. Res. J., 7: 37-41.

Duncan, D.B. (1958). Multiple rang and multiple F test. Biometrics, 11: 1-42.

Esteves, M.T., V.D. Carvalho, M.I.F. de Chitarra, A.B. Chitarra and M.B. Paula (1984). Characteristics of fruits of six guava (*Psidium guajava* L.) cultivars during ripening. II. Vitamin C and tannins contents. Annal do VII Congreso Brasileiro de Fruticultura, 490-500.

Fraser, P.D., M.R. Truesdale, C.R. Bird, W. Schuch and P.M. Bramley (1994). Carotenoid biosynthesis during tomato fruit development. Evidence for tissue specific gene expression. Plant Physiol., 105: 405–413.

Garcia, J.L., M. Ruiz-Altisent and P. Barriero (1995). Effect of foliar applications of $CaCl_2$ on tomato stored at different temperatures. J. Agric. Food Chem., 43: 9–12.

Gracia, J.M., S. Herrera and A. Morilla (1996). Effects of postharvest dips in calcium chloride on strawberry. J. Agric. Food Chem., 44: 30-33.

Grant, G.T., E.R. Morrism, D.A. Rees, P.J.C. Smith and D. Thom (1973). Biological interaction between polysaccharides and divalent cations: The egg-box model. FEBS Lett, 32: 195-198.

Guill'en, F., S. Castillo, P.J. Zapata, D. Mart'ınez-Romero, D. Valero and M. Serrano (2006). Efficacy of 1-MCP treatment in tomato fruit 2.Effect of cultivar and ripening stage at harvest. Postharvest Biol. Technol., 42: 235–242.

Hanson, J.B. (1984). The function of calcium in plant nutrition. In: Tinker, P.B., A. Lauchi (Eds.), Adv. Plant Nutr., Praeger, NY, USA, (1): 149–208.

Hao, X., A.P. Papadopoulos, M. Dorais, D.L. Ehret, G. Turcotte and A. Gosselin (2000). Improving tomato fruit quality by raising the EC of NFT nutrient solutions and calcium spraying: Effects on growth, photosynthesis, yield and quality. Acta Hort., 511: 213-221.

Hao, X. and A.P. Papadopulos (2003). Effects of calcium and magnesium on growth, fruit yield and quality in a fall greenhouse tomato crop grown on rock wool. Can. J. Plant Sci., 83(4): 903-912.

Ho, L.C., D.J. Hand and M. Fussell (1999). Improvement of tomato fruit quality by calcium nutrition. Acta Hort., 481: 463–468.

Hong, J.H. and S.K. Lee (1999). Effect of calcium treatment on tomato fruit ripening. J. Lorean Soc. Hort. Sci., 40 (6): 638-642.

Izumi, H. and A.E. Watada (1994). Calcium treatment effects the storage quality of shredded carrots. J. Food Sci. Technol., 6: 187-194.

Jackson, M.L. (1967). Soil chemical analysis. Prentice Hall, Inc., Engle wood cliff, N.J.

Jamal, J. and C. Kubota (2006). Variation of lycopene, antioxidant activity, total soluble solids and weight loss of tomato during postharvest storage. Postharvest Biology and Technol., 41: 151–155.

Jones, J.B. (1999). Tomato plant culture: In the field, greenhouse and home garden. CRC Press LLC, Florida, 11-53.

Kumar, A., B.S. Ghumanand and A.K. Gupta (1999). Non-refrigerated storage of tomatoes effect of HDPE film rapping. J. Food Sci. Technol., 36: 438–440.

Lopez Camelo, A.F. and P.A. Gomez (2004). Comparison of color indexes for tomato ripening. Hort. Brasileira, 22 (3): 534 – 537.

Lopez, M.V. and S.M.E. Satti (1996). Calcium and potassium-enhanced growth and yield of tomato under sodium chloride stress. Plant Sci., 114:19-27.

Marschner, H. (1993). Functions of mineral nutrients: Macronutrients. In: Marschner H (Ed) Mineral nutrition of higher plants. 2nd ed., 229–299.

Mengel, K. and E. Kirkby (2001). Principles of plant nutrition. 5th ed.: International Potash Institute, Bern, Switzerland.

Mignani, I., L.C. Greve, R. Ben-Arie, H.U. Stotz, C. Li, K. Shakel and J. Labavitch (1995). The effect of GA and divalent cations on aspects of pectin metabolism and tissue softening of ripening tomato pericarp. Physiol. Plant, 93: 108-115.

Moneruzzaman, K.M., A.B.M.S. Hossain, W. Sani and M. Saifuddin (2008). Effect of stages of maturity and ripening conditions on the biochemical characteristics of tomato. American J. Bioch. and Biotec., 4 (4): 336-344.

Nirupama, P., N.B. Gol and T.V. RamanaRao (2010). Effect of postharvest treatments on physicochemical characteristics and shelf life of tomato (*Lycopersicon esculentum* Mill.) Fruits during storage. American-Eurasian J. Agric. Environ. Sci., 9 (5): 470-479.

Njoroge, C.K. and E.L. Kerbel (1993). Effect of postharvest calcium treatment on soluble solids, pH, firmness and color of stored tomato fruits.E. Afr. Agric. Far J., 58 (3): 111-116.

Nonami, H., T. Fukuyama, M. Yamamoto, L. Yang and Y. Hashimoto (1995). Blossom-End Rot of tomato plants may not be directly caused by calcium deficiency. Acta Hort., 396: 107-114.

Paiva, E.A.S., R.A. Sampaio and H.E.P. Marttinez (1998). Composition and quality of tomato fruit cultivated in nutrient solution containing different calcium concentrations. J. Plant Nutr., 21: 2653-2661.

Rady, M.M. (2012). A novel organo-mineral fertilizer can mitigate salinity stress effects for tomato production on reclaimed saline soil. South African J. Botany, 81: 8-14.

Ramana, K.V.R., G.R. Setty, N.V.N. Murthy, S. Saroja and A.M. Nanjundaswamy (1979). Effect of ethephone, benomyl, thiobendazole and wax on color and shelf life of coorg mandarin (*Citrus reticulate* Blanco). Trop. Sci., 21: 265-272.

Richards, L.A. (1954). Diagnosis and improvement of saline and alkaline soils. U.S.D.A. Handbook, 60.

Sahlin, E., G.P. Savage and C.E. Lister (2004). Investigation of the antioxidant properties of tomatoes after processing. J. Food Comp. Anal., 17: 635–647.

Salunkhe, D.K., H.R. Bolin and N.R. Reddy (1991). Storage, processing and nutritional quality of fruits and vegetables (2nd ed.). CRC press, Boston, USA, 147-162.

Sammi, S. and T. Masud (2007). Effect of different packaging systems on storage life and quality of tomato (*Lycopersicon esculentum* var. Rio Grande) during different ripening stages. Internet Journal of Food Safety, 9: 37-44.

Sams, C.E., S.W. Conway, J.A. abbott, R.J. lewis and N. Benshalom (1993). Firmness and decay of apples following postharvest pressure infiltration of calcium and heat treatment. J. Am. Soc. Hort. Sci., 118:623-627.

Saure, M.C. (2001). Blossom-End Rot of tomato (*Lycopersicon esculentum* Mill) a calcium- or a stress-related disorder. Sci. Hort., 90: 193-208.

Sharma R.M., R. Yamdagni, H. Gaur and R.K. Shukla (1996). Role of calcium in horticulture- A review. Haryana J. Hort. Sci., 25 (4):205.

Sharma, S.K. and M. Le Maguer (1996). Lycopene in tomatoes and tomato pulp fractions. J. Food Sci., 2: 107–113.

Shear, C.B. (1975). Calcium-related disorders of fruits and vegetables. Hort. Sci., 10:361-365.

Sheetal, M.C. and L. Ananthanarayan (2007). Enzyme aided extraction of lycopene from tomato tissues. Food Chem., 102: 77–81.

Srivastava, P.C. and U.C. Gupta (1996). Trace elements in crop production. Science Publisher Inc., 88-92.

Stanly, D.W., M.C. Bourne, A.P. Stone and W.V. Wismer (1995). Low temperature blanching effects on chemistry, firmness and structure of canned green beans and carrots. Food Sci., 60: 327-333.

Stelezer, R., A. Lachli and D. Kramer (1975). Intercellular pathways of chloride in roots of intact barely plants. Cytobiologie, 10: 449-457.

Subbiah, K. and R. Perumal (1990). Effect of calcium sources, concentration, stages and number of sprays on physicochemical properties of tomato fruits. South Indian Hort., 38: 20-27.

Trupple, I. and B. Herold (1996). Bedentung von Licht und Farbe Fűr die Qualitätbeurteilung von Frűchten. Bornimer Agrartechni Sche Berichte Heft., 11: 61-73.

Tuna, A.L., K. Cengiz, A. Muhammad, A. Hakan, Y. Ibrahim and Y. B¨ulent (2007). The effects of calcium sulphate on growth, membrane stability and nutrient uptake of tomato plants grown under salt stress. Environ. Exp. Bot., 59: 173–178.

Yeshida, O., H. Nakagaua, N. Ogura and T. Sato (1984). Effect of heat treatment on the development of polygalacturonase activity in tomato fruit during ripening. Plant Cell Physiology, 25 (3):500–509.

تأثير الرش بالكالسيوم على النمو والمحصول وتعفن الطرف الزهري والقدرة التخزينية للطماطم تحت ظروف الأرض الجيرية في دلتا وادي العريش

عبد الواحد كامل محمد البيك

قسم الإنتاج النباتي (خضر)- كلية العلوم الزراعية البيئية بالعريش - جامعة قناة السويس - مصر

أجريت هذه الدراسة خلال الموسمين ٢٠١١ و ٢٠١٢ بمزرعة كلية العلوم الزراعية البيئية بالعريش -شمال سيناء - مصر، وذلك لدراسة تأثير الرش الورقي بالكالسيوم في صورة كالسيوم مخلبى (١,٥ جم / ١لتر) وكلوريد الكالسيوم (١,٥جم /١لتر) على النمو وعفن الطرف الزهري، والمحصول، والقدرة التخزينية لثمار الطماطم، حيث اشتملت التجربة على سبع معاملات: معاملة الكنترول وهى الرش بالماء (T1)، والرش الورقي بمحلول الكالسيوم المخلبى كل خمسة أيام (T2)، والرش الورقي بمحلول الكالسيوم المخلبى كل ١٠ أيام (T3)، والرش الورقي بمحلول الكالسيوم المخلبى كل ١٥ (T4)، والرش الورقي لمحلول كلوريد الكالسيوم كل خمسة أيام (T5)، والرش الورقي لمحلول كلوريد الكالسيوم كل ١٠ أيام (T6)، والرش الورقي لمحلول كلوريد الكالسيوم كل ١٥ يوم (T7)، تم شتل نباتات الطماطم صنف (Gs,12) في ١٢ مايو في كلا الموسمين، أعطت المعاملة T7 أكبر عدد من الأوراق، والعناقيد الزهرية، والأزهار/نبات، بينما أعطت المعاملة (T4) أكبر مساحة ورقية للنبات في كلا الموسمين، كما تأثر تعفن الطرف الزهري للثمار معنويا بمصدرى الكالسيوم، وأعطت المعاملة (T4) أعلى محصول كلى، وأعلى محصول قابل للتسويق /فدان، وتأثرت نسبة المواد الصلبة الذائبة الكلية، وكذلك فيتامين ج في الثمار الطازجة والمخزنة معنويا بمعاملات الكالسيوم فى التجربة، كما تأثرت معنويا كل من درجة اللمعان (*L) وزاوية اللون (°Hue)، حيث انخفضتا بعد التخزين، كما تبدو درجة اللون (*C) ثابتة أو تميل للزيادة في ثمار الطماطم بعد التخزين، وازدادت قيمة اللون (*a) وصبغة الليكوبين بعد ١٤ يوم من التخزين، كما أن معاملة ثمار الطماطم بالكالسيوم قبل الحصاد أدت إلى زيادة محتوى الليكوبين في الثمار الطازجة وبعد التخزين مقارنة بمعاملة الكنترول (T1).

المحكمــــون:

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