J. Plant Production, Mansoura Univ., Vol. 7 (5): 475 - 488, 2016

Tomato Fruit Marketability, Blossom-End Rot Incidence and Quality as Affected by Different Calcium Sources and Time of Application Under Calcareous Soil

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ABSTRACT

Two field experiments were carried out during the winter seasons of 2011/2012 and 2012/ 2013 at The Experimental Farm of The Faculty of Environmental Agricultural Sciences, El-Arish, Suez Canal University, North Sinai Governorate, Egypt. The experiment aimed to study the effect of spraying tomato plants (*Solanum lycopersicum*) GS 12 *cv.* with different calcium sources (calcium chloride, calcium carbonate and calcium chelate as well as without calcium) at different times of application, viz, T_1: spraying one time at full blooming, T_2: spraying one time after 15 days from T_1, and T_3: spraying two times at $T_1 + T_2$ on marketable yield, unmarketable yield (expressed as fruits infected by blossom end rot (BER)), and quality of fruits after 10 days of beginning the storage period. Plants were grown under low tunnels. Spraying tomato plants with Ca^+ as $CaCl_2$ or $CaCO_3$ and other Ca sources increased the marketable yield/ fed. , and also increased fruit shelf life period expressed as decreasing in fruit weight loss and increasing fruit firmness. Foliar application of $CaCl_2$ recorded the lowest values of lycopene contents in both seasons. Time of calcium application did not reflect any significant effect on both marketable and nonmarketable yield as well as marketability (%) and BER incidence (%), and almost pH and TSS values. Application of T3 increased the fruit contents of vitamin C (V.C), while using T2 decreased the content of lycopene. All interaction treatments with control (without application of calcium) decreased marketable yield, marketability (%), but it increased unmarketable yield, BER incidence (%), fruit weight loss and TSS in the 2nd season. Therfore, spraying tomato plants grown under low tunnels in calcareous soil with Ca in different sources had positive effects on both marketable yield and blossom-end rot incidence, total yield, marketability%, BER% and on fruit quality after 10 days of storage period compared to control.

Keywords: Tomato, calcium sources, application time, marketable yield, BER, fruit quality

INTRODUCTION

Tomato (*Solanum lycopersicum*) is one of the major and important vegetable crop in Egypt which consumed in fresh or proccess forms. Tomato fruits contain some important nutritional compunds for human health such as phenolic, vitamins and lycopene which helps counteract the harmful effects of free radical and increase the body defense against several disease and number of cancers, especially prostate cancer and cardiovascular disease (Barber and Barber, 2002; Khan *et al*., 2006; Pila *et al*., 2010).

Calcium plays very important roles as an essential nutrient necessary for plant growth. It is essential for various processes, such as the maintenance of the plant cell structure, resistance to environmental stresses (salinity, drought, chilling, heat, etc.), and most important, as a secondary messenger in signal transduction in plants (Mestre *et al*., 2012). In this connection, many efforts were done to study the effect of calcium on tomato (fruit yield, marketability and storability), and most of invisitigators found a possetive effect in this regard. Application of calcium enhance plant growth and tomato fruit yield and increased the resistance of tomato to fungal disease (Aghofack-Nguemezi and Tachago, 2010; Mestre *et al*., 2012; Aghofack-Nguemezi *et al.,* 2014). Application of Ca (as $CaCl_2$) increased number of fruits / plant and yield/ha.(Ilyas *et al.*, 2014). Spraying tomato plants with Ca-chelate increased total and marketable yield/fed. (Elbeik, 2014). Also it had no significant effect on fruit yield/ fed. (Rab and Haq, 2012). Fruits deformed (BER) occurs mostly during a period of high cellular Ca demand when growth of fruits is accelerated or Ca dilivery to the fruits is limited (Bradfield and Guttridge, 1984; Ho, 1989; Marcelis and Ho, 1999). So, addition of Ca during the period of rapid vegetative growth and fruit setting is very important to overcome fruit deformation due to Ca defficiency. The marketability of honey dew fruits were increased when plants sprayed four tims by Ca (Lester and Grusak, 2004), but it did not affect on cantaloup BER, while it did not affect total marketable fruit yield and number of deformed fruits (Lewandowski, 2003).

Blossom- end rot (BER) is the most common physiological disorder found in tomato and pepper. It may occur in all the tomato-producing areas of the world and has been shown to create losses of up to 50% of production (Casado-Vela *et al.*, 2005). Many investigators found a correlation between the occurrence of BER and Ca nutrition. Byeon, *et al*. (2012) found that application of calcium led to supressed the incidence of BER in pepper which decreased from 62.6 % to 19.2 %. De Freitas and Mitcham (2012) supported the hypothesis that BER is not only related but caused by fruit calcium defficiency. In addition, Nonami *et al*., (1995) suggested that Ca defficiency in the fruit may not be the direct cause of the occurrence of BER in tomato, because fruit that had just started having BER had a similar distribution and concentration of Ca ion as normal fruit. Saure (2014) in a reappraisal concluded that the actual causes of BER are obeviousely the effect of a biotic stress, as salinity, drought, heat, increase in reactive oxygen species (ROS) . Exogenous application of calcium can improve plant growth under

evironmental stress (Tuna *et al*., 2007). Moreover, application of Ca in high concentrations regardless the source can reduce the fruits infected by BER (Mestre *et al.*, 2012; Rab and Haq, 2012; Ilyas *et al.*, 2014).

Because tomato is highly perishable, nearly 30-50% of the production is lost after harvest due to inadequate handling and preservation (Inaba and Crandall, 1986). In the mature treated tomato fruits with calcium could bind with carboxylic groups in pectin to form cross bridges in the cell wall and membrane complexes (Leshem, 1991; Magee *et al*., 2003). This proess reinforce the rigidity of the cell wall (Leshem, 1991). Thus these cross bridges significantly prolong the green-life of mature fruits. Even though some efforts were done to minimize the postharvest losse, enhance the shelf life, delay ripening and improve or maintain the colour and quality such as application of calcium chloride. In this connection, Lester and Grusak (2004) found that spraying honey dew plants four times by calcium increased fruit firmness and decreased fruit weight loss (Bhattarai and Gautam, 2006; Aghofack-Nguemezi and Tachago, 2010; Pila *et al.*,2010). Application of 6% $CaCl_2$ increased tomato fruits shelf life, firmness, delay in fruit colour development, reduced ethylene production, but pH, TSS and TA% were not significantly affected (Senevirathna and Daundasekera, 2010). It could be said that Ca foliar application possitively affected tomato fruit production, and it is very important to overcome Ca defficienc.

So, the aim of this work was to study the effect of supplying tomato plants with calcium in different sources and application times at rapid growth period under calcareous soil on yield and fruits quality after storage period.

MATERIALS AND METHODS

A field experiment was carried out under low plastic tunnels during the winter seasons of 2011/2012 and 2012/ 2013 at The Experimental Farm of The Faculty of Environmental Agricultural Sciences, El-Arish, Suez Canal University, North Sinai Governorate, Egypt. The main objective of this research was to study the effect of spraying tomato plants (*Solanum lycopersicum*) *cv.* GS 12 with four calcium sources (calcium chloride ($CaCl_2$), calcium carbonate ($CaCO_3$), calcium chelate as well as control (without calcium) at three different times of application (T_1: once at full bloom, T_2: once after 15 days from T_1, T_3 twice at T_1 and T_2) on yield and quality of fruits.

This experiment included 12 treatments, which were the combinations between the four calcium sources and the three times of applications. The treatments were randomly arranged in a split plot design in a randomized complete block design with three replications. Calcium sources treatments were randomly arranged in the main plots and time of applications were randomly distributed in the sub – plots. Plants were foliar sprayed with a concentration of 2% from each calcium source (with 1ml/l Tween 20 as spreading agent). The untreated control plants were sprayed with tap water and spreading agent. Treatments were incepted at full bloom stage (40 days after transplanting). Plot area was 45 m^2, which consists of 3 double dripper lines 10 m in length and 1.5 m in width. Tomato seedlings were transplanted on 25th and 29th December in the 1st and 2nd seasons, respectively. The distance between each two plants was 50 cm.

The physical and chemical properties of experimental soil profile from 0-30 cm of soil surface are shown in Table 1.

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

Properties	Season 2011/2012	Season 2012/2013
Soil properties		
Soil texture class	Loamy sand	Loamy sand
Soil chemical properties		
Organic matter %	0.170	0.180
EC (dS m^{-1}) in (1:5) soil water extract	1.32	1.45
pH in (1:2.5) soil water suspension extract	8.2	8.00
Cl^- (meq/l)	5.36	6.48
$CaCO_3$ %	16.21	15.56
Available N (ppm)	15.31	14.88
Available P (ppm)	46.11	44.17
Available K (ppm)	92.88	94.15
Analyses of irrigation water		
EC (dS m^{-1})	6.12	6.74
pH	7.59	7.64
Cl^- (meq/l)	47.04	48.46

All experimental units received compost at a rate of 4 tons/ fed. added in the center of rows (recommended dose). The source of compost was Al-Arabiah for organic fertilizer factory, Sharkia Governorate, Egypt. The physical and chemical properties of compost were as follows: 1.24%, 1.5%

total N, 0.58%, 0.38% total P, 1.15 %, 0.63% total K, 36.56%, 35.3% organic matter, pH (1:10) 8.1, 8.4 and C/N ratio 1:17, 1:14 in the first and second seasons, respectively. Tomato plants received the recommended dose of NPK (124 kg N, 86 kg P_2O_5 and 144 kg k_2O /fed.). One third of fertilizers quantity were added during soil preparation and the other two - thirds were divided into twenty portions and added gradually (two times weekly) through the irrigation water beginning eight days after transplanting. The other conventional practices were applied.

Data Recorded:

I. Yield and Its Components*:*

At red maturity stage, fruits of each plot were harvested, counted and weighed, and the following data were recorded:

-Marketable yield: all fruits at harvest stage within all harvest times were collected, counted, weighed and number of fruits/plant (gm) as well as yield/fed. (ton) were calculated.

-Unmarketable yield: yield/fed. (ton) was measured (expressed as infected fruits with blossom-end rot).

- Marketability (%): {(marketable yield (ton/fed.) / total yield) (marketable + unmarketable yield (ton/fed.))} x 100.

- BER incidence (%): {(unmarketable yield (ton/fed.) / total yield) (marketable + unmarketable yield (ton/ fed.))} x 100.

II. V.C.: It was determined in tomato fruits from the second harvest according (A.O.A.C., 1975).

III. Storability of fruits:

Sample of fruits (30 fruits) from each experimental unit of the second harvest at red stage, free visually from disease and defects were randomly taken and directly transformed to the lab. Fruits were stored at room temperature (average 22.8, 23.3 $^{\circ}$C and 62.1, 62.7 % RH, in 1st and 2nd seasons, respectively). Storage period of fruits were started from 1st to 10th April, and the following physical and chemical parameters were measured:

A- Physical parameters: were determined twice with period 10 days between them as follows:

- **Fruit weight loss (gm):** It was determined as the subtraction between the first and second sample fruit weight.
- **Firmness (kg /cm^2):** It was measured using a manual penetrometer (Model st 207) as average of three reading for each treatment.
- **Decreasing rate in hardness**: It was determined as the subtraction between the first and second reading.

B- Fruit quality: was determined twice as appearance measurements as follows:

- **pH:** using a digital pH meter (Model -671P. JENCO.U.S.A).
- **Lycopene (mg/100gm juice)**: It was determined as the method described by Ranganna (1979).
- **TSS (%)**: It was determined by using Carl Zeis refractometer.

Statistical analysis of the obtained data was carried out according to statistical analysis of variance (Snedecor and Cochran, 1980). Duncan's multiple range tests was used for comparison among means (Duncan, 1958).

RESULTS AND DISCUSSION

1 Marketable Yield

Effect of calcium sources:

Number of fruits/ plant and average fruit weight were significantly increased with foliar application of calcium chloride ($CaCl_2$) and calcium chelate (Ca-chelate) (Table 2). Total yield/ fed. was significantly increased with application of $CaCl_2$ and calcium carbonate ($CaCO_3$) in the 1st season and with all Ca sources in the 2nd one compared to control treatment. The increment in yield and its components due to foliar application of calcium might be attributed to the vital role of calcium as one of the essential macroelements necessary for plant growth. It is used for maintenance of the plant cell structure, resistance to environmental stresses, viz. salinity, drought, chilling, heat, etc. (Mestre *et al*., 2012). Calcium also inhibit the flower abscission and delays leaf senescence in additaion enzyme activation (Mengel and Kirkby, 1978), and stimulate the accumulation of phytoalexin, which implicated in the defense mechanisms of plants against fungal attacks (Zook *et al*., 1987; Aghofack- Nguemezi *et al.*, 2014) and consequantly lead to increase in chloroohyll content, laef area/ plant, photo-assimilation and plant growth. The increment in plant growth increased number of flowers/cluster, number of fruits/cluster, number of fruits/plant, fruits weight and this in turn reflected on yield/ha. (Aghofack-Nguemezi and Tachago, 2010; Mestre *et al*., 2012; Elbeik, 2014; Ilyas *et al.*, 2014). On the other hand, Rab and Haq (2012) found that there were no significant differences between control and foliar application of $CaCl_2$ on tomato fruit weight and yield/fed.

Effect of time of application:

Data in Table 2 reveal that number of fruits/ plant was increased with foliar application of calcium at 15 days from flowering, but fruit weight was increased with T_1 and T_3 in the 1st season. The previous parameters were not significantly affected in the second season. In the same trend, yield/ fed. were not significantly affected by time of Ca application in both season. Non significant differences were found among Ca time of application treatments is probably due to supplying tomato plant with calcium at the critial plant growth period and fruit setting is very important to overcome the high needs of tomato plants to calcium. The obtained results are coincide with those reported by Lewandowski (2003) who found that spraying strawberry plants with $CaCl_2$ at petal fall stage or at 5 days intervals from the previous treatment did not affect total marketable fruit yield, berry fruit weight and number of deformed fruits. Application of calcium chlorid at high rates or at close frequent intervals decreased total marketable yield. Elbeik (2014) found negative effect on tomato plant growth as well as the yield due to foliar application of Ca chloride every 5 days compared to control treatment or application every

15 days, and these ruslts refer to Cl toxicity and its negative effect on plant growth (Srivastava and Gupta, 1996). On the other hand, increasing Ca^{2+} concentration increased total fruit yield. The positive impact of extra Ca^{2+} on fruit yield could be related with the increase of Ca^{2+} levels in leaves favouring the fruit production at expenses of vegetative growth (Rubio *et al.*,2009).

Effect of interaction: Concerning number of fruits/plant, data in Table 3 show significant differences among the interaction treatments on number of fruits/plant. Application of Ca as calcium chloride after 15 days from flowering recorded the highest value in the 1st season, while the same previous treatment as well as the interaction between application of Ca as calcium carbonate (at flowering) were the superior treatments in the sceond season with no significant differences when compared with application of calcium chloride (at flowering) or calcium carbonate (after 15 days from flowering). The same data reveal that fruit weight was significantly increased with application of calcium chelate (after 15 days from flowering) without significant difference with application of calcium chelate twice (at flowering + after 15 days from flowering) or once at flowering as well as with application of calcium chloride at flowering in the second season. Yield/fed. were significantly increased with application of Ca as calcium chloride or calcium carbonate (at flowering or at 15 days after flowering) in the 1st season, while all interactiuon treatments between calcium sources and appliction times increased yield/fed. copmpared to control treatments in the 2nd season. The increments in yield due to application of calcium compared to control may be owe to the vital role of Ca in plant growth and fruit setting and the chosen suitable time for Ca folir application. Calcium ion may also stimulate the accumulation of phytoalexin, a compound known to be implicated in the defense mechanisms of plants as a result of fungal attacks and resistance to bacterial and viral disease (Zook *et al*., 1987; Usten *et al*, 2006). Calcium also increased photosynthetic rate, flowers/cluster, fruit/ cluster, fruit/plant and fresh fruit yield was observed by Rab and Haq (2012), Yang *et al*. (2012) and Aghofack-Nguemezi *et al.* (2014). The increment in yield may be attributed to increase in number of fruits/ plant due to application of Ca which play a role in the inhibition of abscission (Mengle and Kerkby, 1978) and decrease the abscision flowers and fruits (Smit and Combrink, 2005; Ilyas *et al*., 2014). Additionally, application of Ca at the critical periods of plant growth, rapid growth and fruit setting is important to increase marketability of fruits (Lester and Grusak, 2004), at which fruits deformed occurs mostly during a period of high cellular Ca demand, when fruit growth is accelerated or Ca dilivery to the fruits is limited (Bradfield and Guttridge, 1984; Ho, 1989; Marcelis and Ho, 1999).

2- Unmarketable yield: unmarketable yield was estimated as fruits infected by blossom- end rot (BER).

Effect of calcium sources:

Data in Table 2 reveal that there were significant differences detected among Ca sources on unmarketable yield components. Control treatment recorded the highest values of infected yield with BER incidence per fed. compared to all tested sources of calcium. Application of calcium as calcium carbonate or calcium chelate recorded the lowest values of unmarketable yield fed. The increment in BER incidence on yield observed with control treatment may be owe to the low Ca content in fruit tissue (Elbeik, 2014) which resulted from Ca deficiency in its tissues (Mengel and Kirkby, 2001). In this connection Del-Amor and Marcelis (2003) showed that the BER in tomato fruit is a physiological disorder resulting from calcium deficiency and it may occur in all the most producing areas of the world (Casado-Vela *et al*., 2005). The decrease of BER yield due to application of Ca compared to control treatment may be due to the critical role of Ca in maintaining plant cells structure and its resistance to environmental stress (Mester *et al.*, 2012) and stability of biomembranes, and Ca-polyglacturonates required in the middle lamella for cell wall stability (Marschner, 1986). These results are coincide with those reported by Schmitz-Eiberger *et al*. (2002), Rubio *et al.* (2009), Byeon *et al*. (2012), Mester *et al.* (2012), Rab and Haq (2012) and Ilyas *et al.* (2014) who concluded that application of Ca in high concentrations regardless the source can reduced the fruits infected by BER.

Effect of time of application:

Data in Tale 2 reveal that there were no significant differences among the Ca times of application treatments on BER incidence in tomato yield/ fed. These results may be attributed to application of calcium was practiced at the rapid vegetative growth and fruit setting in the same time at the period of high cellular Ca demand. Byeon *et al.* (2012) showed that during the first fruit setting period, more than 60% of pepper fruits showed the symptoms of blossom-end rot and calcium application during the rapid vegetative growth and fruit setting period could be suggested as a preventive step to overcome the local Ca deficiency inducing BER of pepper fruits. The insignificant differences among the treatments due to spraying Ca at flowering or setting period may be also due to the high content of calcium in fruits and consequantly Ca did not reflect an effect on deformed fruits as mentioned by Lewandowski (2003) on strawberry.

Effect of interaction:

Data in Table 3 reveal that BER of tomato fruits was increased in all control interaction treatments specially in the second season expressed as infected yield / fed. In addition, sparying tomato plants with Ca as calcium chelate combined with T_1, T_2 and T_3 recorded the lowest values of infected yield with BER followed by the interaction between calcium carbonate and its times of application and spraying of Ca as calcium chloride at the three times of application, respectively. It is clear that there were no significant differences among the time of application with the three sources of calcium which the effect of application time is weak. So, addition of Ca to tomato plants specially at flowering or fruit setting is very important to decrease

tomato fruit incidence with BER. In this connection, Goodwin (1978) showed that the concentration of GA in tomato pericarp is high at fruit development. At this time, fruit growth by cell expansion is rapid, especially at fruit blossom-end. This phase is of greatest risk of BER incidence. Whereas GA concentration is high, the concentration of Ca^{2+} is strictly reduced in this period, and this rapid growth rates may increase the risk that the tissue content of Ca^{2+} falls below the critical level required for cell wall stabilization and membrane integrity (Marschner, 1993). Saur (2014) explained that under condition of apoplastic Ca, the plasma membrane may become leaky, leading to cell plasmolysis, cell death and thus BER incidence. In this case, spraying plants with Ca^{2+} salts during fruit set and development may help to reduce the incidence of BER. Byeon *et al*. (2012) came to silmilar results with spraying pepper plants with Ca which decreased the incidence of BER from 62.6 % to 19.2 %.

Table 2: Effect of calcium sources and its time of application on marketable and unmarketable yield of tomato during 2011/2012 and 2012/2013 seasons.

Parameters / Treatments	Number of fruits/plant	Avg. fruit weight (gm)	Marketable yield/fed. (ton)	Unmarketable yield/fed. (ton)	Number of fruits/plant	Avg. fruit weight (gm)	Marketable yield/fed. (ton)	Unmarketable yield/fed. (ton)
Calcium sources		First season				Second season		
Without calcium	33.2c	63.4c	19.1b	1.20a	34.1c	61.0c	19.3b	1.06a
Calcium chloride	50.8a	59.8c	27.2a	0.75b	48.5a	62.9bc	28.0a	0.76b
Calcium carbonate	43.2b	68.1b	26.9a	0.38c	44.4b	68.8b	28.3a	0.45c
Calcium chelate	26.2d	82.0a	20.1b	0.33c	36.0bc	80.7a	27.2a	0.33c
Time of application		First season				Second season		
T1 (at flowering)	33.5b	73.3a	22.8a	0.63a	37.3a	71.0a	24.9a	0.68a
T2 (after 15 days)	45.2a	63.4b	23.0a	0.72a	44.7a	65.9a	26.9a	0.61a
T3 (at flowering + 15 days)	36.2b	68.3ab	22.5a	0.68a	40.3a	68.2a	25.3a	0.67a

***Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.**

Table 3: Effect of interaction between calcium sources and its time of application on marketable and unmarketable yield of tomato during 2011/2012 and 2012/2013 seasons.

Treatments	Parameters	Number of fruits/plant	Avg. fruit weight (gm)	Marketable yield/fed. (ton)	Unmarketable yield/fed. (ton)	Number of fruits/plant	Avg. fruit weight (gm)	Marketable yield/fed. (ton)	Unmarketable yield/fed. (ton)
Calcium sources	Time of application		First season				Second season		
Without calcium	At flowering	34.7g	60.4efg	19.3c	1.07b	35.3c	58.7ef	19.3c	1.05a
	After 15 days	33.3h	63.5def	18.5c	1.48a	32.3c	61.3ef	18.5c	1.09a
	At flowering+15 days	31.5i	66.3de	19.5c	1.17b	34.4c	62.9def	20.2bc	1.05a
Calcium chloride	At flowering	38.2f	75.2bc	26.8ab	0.75c	39.8bc	73.3bcd	27.3ab	0.84b
	After 15 days	65.7a	47.7h	29.2a	0.76c	55.2a	55.3f	28.6a	0.69b
	At flowering+15 days	48.4c	56.6fg	25.6b	0.74c	50.3ab	59.9ef	28.1a	0.76b
Calcium carbonate	At flowering	38.8e	80.9b	29.2a	0.39d	39.8bc	77.2abc	28.8a	0.49cd
	After 15 days	51.8b	54.1gh	26.1ab	0.27d	52.5a	62.0ef	30.3a	0.33d
	At flowering+15 days	39.2d	69.4cd	25.4b	0.50cd	40.8bc	67.0cde	25.7abc	0.53c
Calcium chelate	At flowering	22.4l	76.8b	16.1c	0.32d	34.0c	75.0abc	24.1abc	0.33d
	After 15 days	30.2j	88.4a	24.9b	0.36d	38.4c	85.1a	30.3a	0.32d
	At flowering+15 days	25.8k	80.8b	19.5c	0.30d	35.6c	82.2ab	27.2ab	0.32d

***Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.**

3- Marketability (%) and unmarketability (BER incidence %)

Effect of calcium sources:

The data in Table 4 reveal that all sources of Ca applied increased the marketability % of tomato fruits and decreased BER% in the 1st season, while spraying with Ca as Ca- carbonate or Ca-chelate recorded the highest and lowest values of both marketability % and BER incidence %, respectively in the second one. Control tratments recorded the lowest and highest values of marketability % and BER incidence % in both seasons, respectively. Foliar application of Ca increased the fruit marketability % from 98.58, 98.38 and 97.29% for Ca-carbonate, Ca-chelate and Ca chloride in the 1st season, respectively compared to (93.9%) control treatment and from 98.65, 98.40 and 97.25% for Ca - chelate, Ca-carbonate and Ca-chloride in the 2nd season, respectively compared to (94.74%) control treatment. Application of Ca decrease of BER% incidence from 6.% control treatment to 1.42, 1.62 and 2.71% for Ca-carbonate, Ca-chelate and Ca- chloride in the 1st season, respectively and from 5.26% control treatment to 1.35, 1.60, and2.75% for Ca-chelate, Ca-carbonate and Ca-chloride in the 2nd season, respectively. The increment of fruit marketability % and decrease in BER% incidence due to application of Ca may be owe much to the increase of marketable yield and decrease in infected yield with BER per fed. (Table 2) compared to control treatmets. These results under calcareous soil and salinity water irrigation which increase soil pH and consequantly reduce the availability or loss or fixation of almost all nutrients (Imas, 2000) and foliar application of Ca to plant is required for middle lamella and cell wall stability (Marschner, 1986; Saur, 2014) and for building new cell walls and membranes, and as a cytosolic signal in the form of a counter-cation in the enlarging vacuole (Ho and White, 2005). In addition, it affected the activity of the ascorbate–glutathione enzymes which lead to more calcium in tomato fruits (Waterland *et al*., 2010; Setha, 2012) .This could cause the break-down of cellular homeostasis, the inhibition of other enzymes responsible for H_2O_2 detoxification, and ultimately an increase of lipid peroxidation in tomato plants therefore, BER incidence (Schmitz-Eiberger *et al*., 2002; Mestre *et al*., 2012), Ca application also supressed the induction and the effect of GA and consequantly inhibited the development of BER (Saur, 2014). Additionally, Ca defficiency create losses up to 50 % of tomato yield in all tomato producing areas of the world (Casado-Vela *et al.,* 2005) and application of Ca increased calcium concentration in fruit tissues and supressed the incidence of BER, which decreased from 62.6 % to 19.2 % (Byeon *et al*., 2012). Rab and Haq (2012) found that application of Ca at concentration of 0.6% decreased BER % incidence in tomato fruits from 17.56% in control to 10.12%. The same result was found by Ilyas *et al.,* (2014) who found that application of Ca decreased BER% in tomato fruits from 15.97% as control treatment to 8.22% with Ca application. Ca foliar application increased tomato fruit marketability and decreased BER% incidence (Hao and Papadopoulos, 2004; Rubio *et al.,* 2009).

Effect of application time:

The data in Table 4 illustrate that there were no significant differences among all application times on fruit marketability% and BER% incidence in both seasons. These results may be attributed to the effect of application times on marketable yield per fed. and unmarketable yield (infected fruits) (Table 2) wherin the same trend of resules were found. As well as it may be owed to apply of calcium at the rapid vegetative growth of tomato plants and fruit setting periods wherein Ca concentration in fruits decreased after flower anthesis, and fruit growth is accelerated and fruits needs high cellular Ca demand (Bradfield and Guttridge, 1984; Ho, 1989; Marcelis and Ho, 1999). Lester and Grusak (2004) found that the marketability of honey dew fruits were increased when plants sprayed four tims by Ca application. Calcium application during the rapid vegetative growth and fruit setting periods may increase the concentartion of Ca in setting fruits as a preventive step to overcome the local Ca deficiency inducing blossom-end rot of pepper fruits (Lester and Grusak, 2004; Byeon *et al*., 2012).

Effect of interaction:

The data in Table 5 reveal that the interaction between Ca foliar application as calcium carbonate with treatments of T_1 or T_3 as well as application of Ca as calcium chelate with T_1, T_2 and T_3 were the superior interaction treatments in 1st season and 2nd seasons wherein, it recorded the highest values of fruit marketability% and the lowest values of BER% incidence. On the other hand, control treatments recorded the lowest values of fruit marketability % and highest BER% incidence values in both seasons. It could be concoluded that regardless the time of Ca application, application of calcium as carbonate or chelate sources increased the fruit marketability% and decreased BER% incidence compared to Ca as chloride or without application of Ca in both seasons. The obtained results may be owed to the effect of Ca application on marketable yield and unmarketable yield which show decrease in infected fruit yield (Tables 4, 5), as well as to the supply of calcium at the critical stage of plant growth and fruit setting which need more calcium. In this connection, Elbeik (2014) found that spraying tomato plants with ca as Ca-chelate every 15 days recorded the highest value of marketable yield, while sprying with Ca as calcium chloride every 5 days recorded the lowest value in this respect. In addition, application of Ca as Ca-chelate every 5 or15 days recorded the lowest values of BER%, while sprying Ca as calcium chloride every 15 days recorded the highest BER%. On the other hand, Lewandowski (2003) found that number of strawberry deformed fruits did not significantly affected by spraying with $CaCl_2$ at petal fall stage or 5 days intervals from petal fall stage.

Table 4: Effect of calcium sources and its time of application on marketability and BER % of tomato during 2011/2012 and 2012/2013 seasons.

Treatments	Parameters Marketability (%)	Unmarketability (BER) (%)	Marketability (%)	Unmarketability (BER) (%)
Calcium sources	First season		Second season	
Without calcium	93.90b	6.10a	94.74c	5.26a
Calcium chloride	97.29a	2.71b	97.25b	2.75b
Calcium carbonate	98.58a	1.42b	98.40a	1.60c
Calcium chelate	98.38a	1.62b	98.65a	1.35c
Time of application	First season		Second season	
T1 (at flowering)	97.19a	2.81a	97.12a	2.88a
T2 (after 15 days)	96.90a	3.10a	97.41a	2.59a
T3 (at flowering+15 days)	97.01a	2.99a	97.26a	2.74a

***Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.**

Table 5: Effect of interaction between calcium sources and its time of application on marketability and BER (%) of tomato during 2011/2012 and 2012/2013 seasons.

Treatments	Parameters	Marketability (%)	Unmarketability (BER) (%))	Marketability (%)	Unmarketability (BER) (%)
Calcium sources	Time of application	First season		Second season	
Without calcium	At flowering	94.75c	5.25b	94.81d	5.19a
	After 15 days	92.61d	7.39a	94.44d	5.56a
	At flowering+15 days	94.33c	5.67b	94.98d	5.02a
Calcium chloride	At flowering	97.26b	2.74c	96.97c	3.03b
	After 15 days	97.42b	2.58c	97.41bc	2.59bc
	At flowering+15 days	97.19b	2.81c	97.37bc	2.63bc
Calcium carbonate	At flowering	98.70a	1.30d	98.32ab	1.68cd
	After 15 days	98.99a	1.01d	98.91a	1.09d
	At flowering+15 days	98.05ab	1.95cd	97.97abc	2.03bcd
Calcium chelate	At flowering	98.06ab	1.94cd	98.37ab	1.63cd
	After 15 days	98.58a	1.42d	98.87a	1.13d
	At flowering+15 days	98.48a	1.52d	98.71a	1.29d

***Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.**

4 Physical Parameters

Effect of calcium sources:

Concerning fruit weight loss, the data presented in Table 6 show that control treatmrnt significantly increased fruit weight loss in both seasons, and application of calcium as calcuim carbonate recordrd the lowest values of fruit weight loss in the 1st season compared to calcium chloride and calcium chelate, with no significant differences among calcium chloride, calcuim carbonate and calcium chelate in the second season. As regard to fruit firmness, the same data show that there were no significnt differences among all sources of Ca at the initial time of storage in the 1st season, but firmness at the end of storage period increased with application of Ca as calcium chloride without significant differences when compared with calcuim carbonate and calcium chelate. In addition, spraying with Ca as Ca carbonate recorded the highest value of firmness at the initial time of storage compared to control treatment, and spraying with both calcium chloride and aclcium chelate, but at the end of storage period, control treatment recorded the lowest value of firmness compared to the other Ca applied sources. The increments in weight loss and decrease in firmness in control treatment compared to application of calcium may be owe to the vital role of Ca in building plant cell wall middel lamella and stability of bio-membranes, and Ca-polyglacturonates required in the middle lamella for cell wall stability and thus limit cell expantion (Marschner, 1986; Saur, 2014). The effect of Ca application on tomato fruits weight loss and firmness are in harmony with those reported by Bhattarai and Gautam (2006) who observed that weight loss of tomato fruits during storage period was lower than control treatment due to application of $CaCl_2$. This may be owe to the role of Ca in plant as an important nutrient in structural of middle lamellae. Softening of fruits is mainly due to weaking of middle lamella during ripenning. Calcium helps to bind polygalactonic acid each other,formation of cation cross bridges between uronic acid groups (Sams *et. al.,* 1993) which may induce lower weight loss and higher fruit firm and make the membrane strong and rigid. Calcium is essential for stability of biomembranes, and Ca- polyglacturonates are required in the middle lamella for cell wall stability (Marschner, 1986). Spraying calcium clorid can delay tomato fruit maturity and senescence and it may increase fruit firmness and organic acid content, decrease and delay peak value of respiration, restrain the increasing of membrane osmosis (Schmitz-Eiberger *et al.,* 2002; Chen *et al.,* 2006). The increment of hardness due to application of Ca my be also attributed to the significant increment of calcium content in both inner and outer pericarp regions of fruits. Calcium chloride treated tomatoes produced ethylene at significantly lower levels and delayed climacteric peak

to a certain extent and this consequantly showed significantly higher firmness (Senevirathna and Daundasekera, 2010). The increment in hardness as regard to increase in shelf life due to application of Ca compared to control treatment may be attributed to calcium is bound to calmodulin, which is one of the most common intracellular receptors to modulate many physiological processes. Aghofack-Nguemezi and Tachago (2010) found that application of fertilizeres containing Ca gave fruits with longer duration of ripening period than those from control plants. The length of time between the red-ripe stage and the trickling of 100% of tomato fruits (shelf-life) was mostly significantly prolonged, and it may be owe to Ca retained fruits firmness, calcium ion can delay the ripening and senescence by stabilizing cell membrane and increasing the rigidification of monolayers. Also several calcium-pectate interactions make the cell wall firmer (Carpita and McCann, 2000). In addition, foliar application of Ca as $CaCl_2$ or Ca-chelate increased tomato fruit firmness (Rab and Haq, 2012; Elbeik, 2014).

Effect of application time:

Data presented in Table 6 reveal that spraying tomato plants with Ca once at flowering recorded the highest fruit weight loss compared to T_3 treatment. This means that the rate of fruit weight loss in case of sprying two times (T_3) is higher than spraying one time, specially at flowering stage. This situation was reversed in the 2nd season, which did not reflect significant differences among application times regarding fruit weight loss. It is obevious from the same data that Ca application times had no significant effect on tomato fruit firmness in both seasons. It could be concluded that the effect of application time on fruit weight loss is fluctuate, in its effect on firmness parameters. The fluctuation effect of time of application on fruit weight loss and its insignificant effect on firmness paramrters may be attrhibuted to that the supply of Ca in conformity plant growth stages wherein the requirements of Ca is cumulative after anthesis (Byeon *et al.,* 2012) and fruit growth which a period of high cellular Ca demand (Bradfield and Guttridge, 1984; Ho, 1989; Marcelis and Ho, 1999). Increasing Ca concentration may stimulate the role of ABA in fruit growth development (Aghofack-Nguemezi *et al*., 2014) and this lead to more calcium content in tomato fruits (Waterland *et al*., 2010; Setha, 2012) and this in turn increase the fruit firmness and consequantly the shelf life of tomato fruits.

Effect of interaction:

The data in Table 7 reveal that interaction treatments of control increased weight loss in both seasons, while the interaction between Ca-carbonate x spraying twice (T_3) as well as the interaction between application of Ca-chelate x T_1 recorded the lowest fruit weight loss in the 1st and 2nd seasons, respectively. Concerning fruit frmness, the data illustrate that firmness at the initial time of storage in the 1st season did not show significant effect by the interaction treatments, while it had significant effecte in the 2nd season. The highest firmness values were observed with foliar application of Ca as Ca-chloride twice and application of Ca as Ca-carbonate one time at after 15 day or two times at flowering + after 15 days of flowering in the second season. Similar trend for firmness was observed at the end of storage peroid in the second season. Control interaction treatments recorded the lowest fruit firmness values in both seasons. In this connection Lester and Grusak (2004) found that spraying honey dew plants with Ca (with regardless of sources) four times increased fruit firmness due to its higher content of Ca compared to control plants.

Table 6: Effect of calcium sources and its time of application on some physical parameters of tomato fruits during 2011/2012 and 2012/2013 seasons.

Parameters / Treatments	Fruit weight loss (gm)	Firmness at the initial time	Firmness after 10 days of storage	Decreasing rate in hardness	Fruit weight loss (gm)	Firmness at the initial time	Firmness after 10 days of storage	Decreasing rate in hardness
Calcium sources		First season				Second season		
Without calcium	4.80a	2.92a	2.31b	0.67a	3.43a	1.52c	1.29b	0.232a
Calcium chlorid	3.77ab	3.42a	3.03a	0.38b	2.00b	2.61b	2.38a	0.232a
Calcium carbonate	2.88b	3.19a	2.76ab	0.44b	2.60b	3.11a	2.79a	0.317a
Calcium chelate	3.35b	3.32a	2.92ab	0..35b	2.05b	2.48b	2.27a	0.211a
Time of application		First season				Second season		
T1 (at flowering)	4.40a	3.28a	2.82a	0.462a	2.14a	2.07a	1.84a	0.227a
T2 (after 15 days)	3.69ab	3.08a	2.59a	0.492a	3.12a	2.51a	2.22a	0.293a
T3 (at flowering+15 days)	3.01b	3.28a	2.86a	0.433a	2.31a	2.71a	2.49a	0.224a

***Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.**

Table 7: Effect of interaction between calcium sources and its time of application on some physical parameters of tomato fruits during 2011/2012 and 2012/2013 seasons.

Treatments	Parameters	Fruit weight loss (gm)	Firmness at the initial time	Firmness after 10 days of storage	Decreasing rate in hardness	Fruit weight loss (gm)	Firmness at the initial time	Firmness after 10 days of storage	Decreasing rate in hardness
Calcium sources	Time of application	First season				Second season			
Without calcium	At flowering	4.94ab	3.02a	2.39cd	0.623a	3.30ab	1.26d	1.06f	0.200a
	After 15 days	5.29a	2.80a	2.17d	0.633a	3.20ab	1.77bcd	1.49def	0.287a
	At flowering +15 days	4.19a-d	2.93a	2.37cd	0.770a	3.80a	1.52cd	1.31ef	0.210a
Calcium chloride	At flowering	3.84b-e	3.37a	3.00ab	0.367a	1.70d	1.97bcd	1.83c-f	0.133a
	After 15 days	3.87b-e	3.25a	2.83abc	0.417a	2.89abc	2.47abc	2.23a-d	0.237a
	At flowering +15 days	3.57cde	3.63a	3.27a	0.367a	1.40d	3.40a	3.07a	0.327a
Calcium carbonate	At flowering	4.64abc	3.35a	2.90ab	0.450a	2.09cd	2.70ab	2.36abc	0.340a
	After 15 days	2.84e	3.13a	2.64bcd	0.493a	3.37ab	3.47a	3.08a	0.383a
	At flowering +15 days	1.15f	3.10a	2.73bc	0.367a	2.34bcd	3.15a	2.92ab	0.227a
Calcium chelate	At flowering	4.16a-d	3.37a	2.97ab	0.407a	1.45d	2.33a-d	2.10b-e	0.233a
	After 15 days	2.74e	3.15a	2.73bc	0.423a	3.00abc	2.34a-d	2.07b-e	0.267a
	At flowering +15 days	3.14de	3.45a	3.07ab	0.233a	1.70d	2.77ab	2.63abc	0.133a

***Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.**

5Fruit Quality

Effect of calcium sources:

Concerning the content of V.C. the data in Fig.1 show that there were no significant differences among all sources of applied Ca on V.C. content in tomato fruits in both seasons. The same trend was found with pH in both seasons as well as TSS in the 1st season wherein did not significantly affected by spraying tomato plants with any Ca source (Table 8), but TSS in the 2nd season was increased significantly with Ca foliar application compared to control treatment. Application of Ca as Ca- chelate was the superior treatment for increasing TSS values at the initial and storage time without significant differences when compared with the other applied sources (Ca-chloride, Ca-carbonate) while control treatment recorded the lowest values at both the initial and the end of storage period. As regard to lycopene content, the same data reveal that foliar application of Ca as Ca-chloride recorded the lowest values at initial time of storage and at the end of storage period in both seasons followed by Ca-carbonate. The highest increment in lycopene content during the storage period was observed with control treatment(5, 3.36%), while the other sources of Ca recorded less lycopene content specially with Ca-carbonate (1.2, 2.46%) followed by Ca-chloride (3.23, 2.86%) and Ca-chelate (3.8, 2.9%) in the 1st and 2nd season, respectively. The decrease in lycopene content due to application of Ca during storage period compared to control treatment may be owed to the role of Ca in ripening processes. Fruit ripening is a result of many processes including chlorophyll breakdown and synthesis of new carotenoids (Brady, 1987; Giovannoni, 2001). Ca application also inhibit the activity of pectinmethylesterase and polygalaturo-nase which are enzymes implied in the degradation of the cell wall pectin (Magee *et al.,* 2003). Thus these findings significantly prolong the green-life of mature fruits and consequently increase fruits shelf life. The decrease in lycopene during storage period of fruits due to application of Ca may be owed to spraying Ca can delay tomato fruit maturity, ripening, and prolongation of the shelf life of the red-ripe ones as well as fruit senescence (Sharma *et al.,* 1996; Chen *et al*., 2006; Aghofack-Nguemezi and Tatchago, 2010). On the other hand, control treatments had high lycopen content after 14 days of storage compared to apllication of Ca as $CaCl_2$ or Ca-chelate (Elbeik, 2014). In addition, TSS content in fruits significantly increased with $CaCl_2$ treatment. However, there was no consistent relationship between $CaCl_2$ treatment and the TSS content of tomato fruits at the end of the storage period. Similarly, there was no consistent relationship between $CaCl_2$ treatment and titratable acidity (TA %) of tomato fruits. However, spraying 6% $CaCl_2$ reflected a significant reduction in TA % in fruits. Although it was expected that pH would increase with higher $CaCl_2$ levels according to TA % values, pH was reduced to insignificant levels with the increase in $CaCl_2$ concentration (Senevirathna and Daundasekera, 2010). Pila *et al.,* (2010) found that control show decrease in TA% and increase in TSS, lycopene and pH compared to Ca application. This may be owe to that the decline of acidity is attributed to increase in citric acid glyoxylase activity during ripening or reduction in acid content may be due to their conversion into sugars and further utilization in metabolic process during storage (Rathore *et al.,* 2007). There were no significant effect between foliar application of Ca as $CaCl_2$ and control treatment on TSS in tomato fruits (Rab and Haq, 2012), while control treatment reflected high organic acid %, and low soluble sugar % and V.C. content in tomato fruits compared to application of Ca as $CaCl_2$ (Yang *et al.,* 2012).

Effect of application time:

As regard to V.C. content, the data in Fig. 2 reveal that spraying tomato plants with Ca two times (T_3) recorded the highest value of V.C. content (19.2, 19.8) compared to spraying one time at flowering (17.1, 18.0) or one time after 15 days of flowering (17.2, 17.9)) in the 1st and 2nd seasons, respectively. The same data (Table 8) reveal that pH at the initial of storage and the end of storage period did not significantly affect in both seasons as wll as TSS at the initial time in 2nd season, but spraying plants once after 15 days of flowering or twice increased TSS in fruits at the end of storage period in the second season. In this connection Lewandowski (2003) found that spraying strawberry with Ca at petal fall stage or 5 days intervals from petal fall stage had no effect on TSS and TA. Bhattarai and Gautam (2006) found that there were no significant

effect among different Ca concentration on pH, TSS and TA % in tomato fruits during the storage period. On the other hand, Rubio et al., (2009) found that increasing Ca concentration decreased TSS in fruits. Regarding lycopene content, the same data reveal that spraying tomato plants with Ca at flowering increased the content of lycopene in both 1st and 2nd dates of storage periods without significant differences when compared with spraying two times at the end time of storage, while spraying one time after 15 days of flowering recorded the lowest values in this respect.

Effect of interaction:

Data in Fig. 3 and Table 9 show significant differences among the interaction treatments due to foliar application of Ca in different sources and its application times on tomato fryit quality in both seasons. As regard to the content of V.C., the data in Fig. 3 show that sparying tomato plant with Ca as Ca-carbonate or Ca-chelate twice (at flowering + after 15 days of flowering) were the superior treatments which recorded the highest values for V.C. content in both seasons in comparison with the other interaction treatments. Regarding pH, lycopene and TSS contents, the data in Table 9 illustrate that pH of tomato fruits at both the initial and the end of storage period were not significantly affected by such interaction treatments. In addition, the conteent of lycopen did not have a constant trend in the 1st season which significantly increased at the initial time with spraying one time at flowering by Ca-carbonate, but at the end of storage it significantly increased with Ca- chelate twice (T_3). On the other side, lycopen content had a constant trend in the 2nd season. Application of Ca twice (T_3) without Ca or with Ca-chelate recorded the highest lycopene content, while it recorded the lowest value, approximately when plants treated two times with Ca- carbonate. In this connection, Elbeik (2014) found that spraying tomato plants with Ca with regardless of sources ($CaCl_2$, Ca-chelate) at different time of application (every 5, 10 and 15 days) increased lycopene content in tomato fruits during storage compared to control. Concerning TSS, the data reveal that spraying of Ca as Ca-carbonate twice or Ca-chelate on time after 15 days of flowering in the 1st season were the superior interaction treatments for increasing TSS in 1st and 2nd dates of storage periods, respectively.While, spraying with Ca as Ca-chloride twice was the superior treatments in 2nd season only. In this connection Lewandowski (2003) found that spraying with $CaCl_2$ did not show any effect on TSS and TA in strawberry fruits. TSS % and pH at the end of storage period in tomato fruits were significantly increased with application of $CaCl_2$. In this connection, control treatment or application of Ca-chelate were the superior treatments for V.C. content at the end of storage period (Elbeik, 2014).

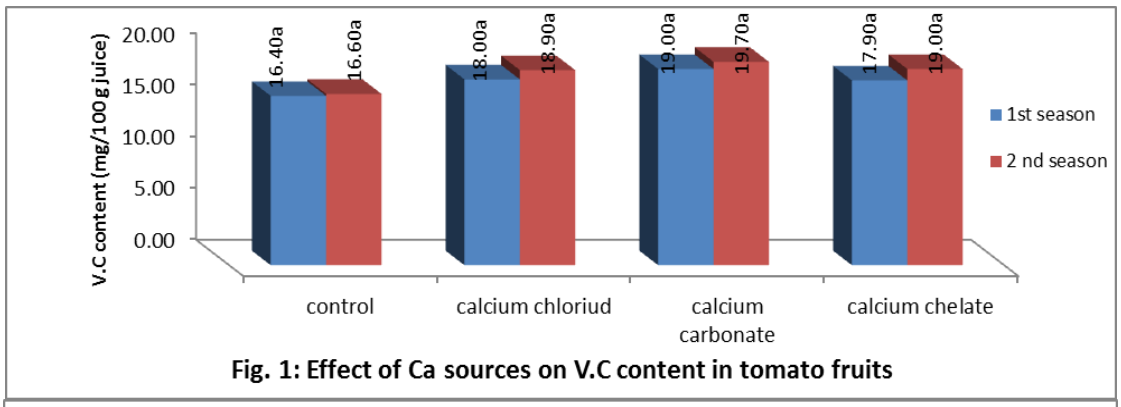

Fig. 1: Effect of Ca sources on V.C content in tomato fruits

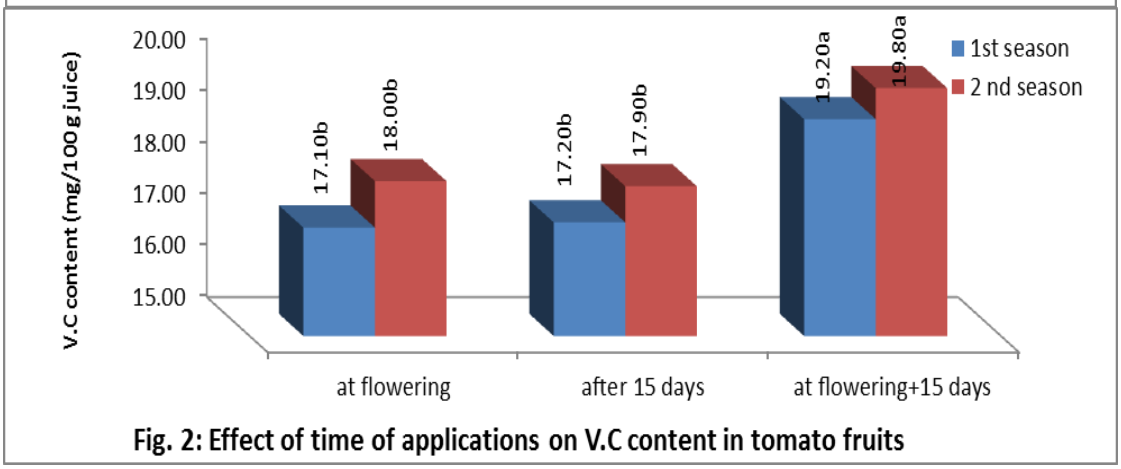

Fig. 2: Effect of time of applications on V.C content in tomato fruits

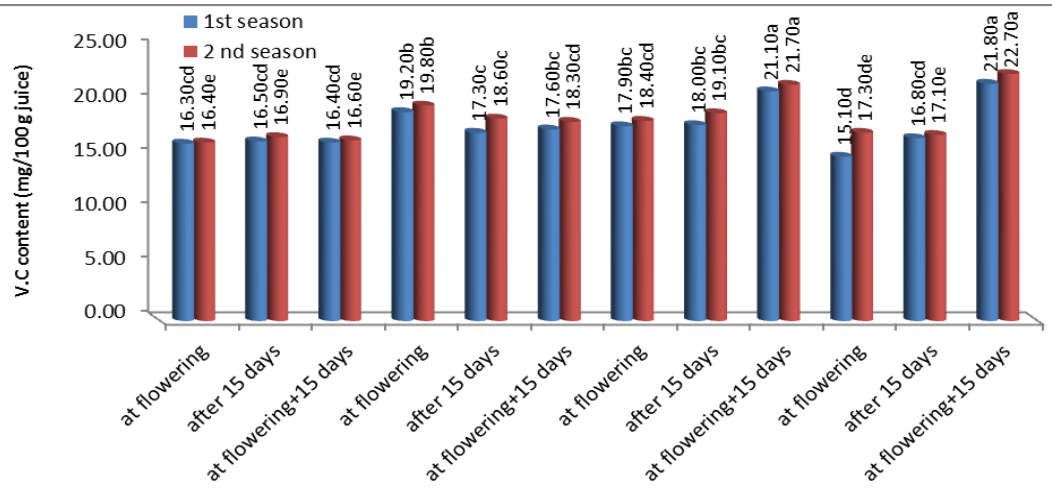

Fig. 3: Effect of interaction between Ca sources and time of applications on V.C content in tomato fruits

Table 8: Effect of calcium sources and its time of application on some fruit quality parameters of tomato during 2011/2012 and 2012/2013 seasons.

Parameters / Treatments	pH at initial time	pH after 10 days	Lycopene (mg/100gm Juice) at the initial time	Lycopene (mg/100g Juice) after 10 days	T.S.S (%) At initial time	T.S.S (%)after 10 days	pH at initial time	pH after 10 days	Lycopene (mg/100g Juice) at initial time	Lycopene (mg/100g Juice) after 10 days	T.S.S (%) At initial time	T.S.S (%) after 10 days
Calcium sources			First season						Second season			
Without calcium	4.53a	5.28a	0.049ab	0.099a	7.81a	9.67a	4.72a	5.13a	0.075a	0.108a	7.48b	7.97b
Calcium chloride	4.72a	5.40a	0.033b	0.043c	8.08a	9.08a	5.08a	5.38a	0.045c	0.074c	8.45ab	8.82a
Calcium carbonate	4.89a	5.33a	0.053a	0.065b	7.57a	9.28a	5.22a	5.43a	0.064b	0.089b	8.43ab	8.71a
Calcium chelate	4.88a	5.20a	0.052a	0.090a	7.60a	9.98a	5.18a	5.33a	0.067ab	0.096ab	8.49a	8.94a
Time of application			First season						Second season			
T1 (at flowering)	4.60a	5.26a	0.060a	0.093a	7.44a	8.96a	4.92a	5.22a	0.079a	0.108a	7.71a	8.19b
T2 (after 15 days)	4.84a	5.40a	0.038b	0.054b	7.85a	9.72a	5.10a	5.33a	0.047c	0.072b	8.33a	8.66a
T3 (at flowering + 15 days)	4.83a	5.25a	0.042b	0.076a	8.02a	9.83a	5.13a	5.40a	0.063b	0.096a	8.61a	8.97a

***Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.**

Table 9: Effect of interaction between calcium sources and its time of application on some fruit quality parameters of tomato during 2011/2012 and 2012/2013 seasons.

Treatments	Parameters	pH at initial time	pH after 10 ays	Lycopene (mg/100gm Juice) at initial time	Lycopene (mg/100gm Juice) after 10 days	T.S.S (%) at initial time	T.S.S (%) after 10 days	pH at initial time	pH after 10 days	Lycopene (mg/100gm Juice) at initial time	Lycopene (mg/100gm Juice) after 10 days	T.S.S (%) at initial time	T.S.S (%) after 10 days
Calcium sources	Time of application			First season						Second season			
Without calcium	At flowering	4.53a	5.33a	0.067ab	0.101b	7.81ab	9.50abc	4.69b	5.03a	0.084ab	0.113b	7.40d	7.86e
	After 15 days	4..50a	5.29a	0.031e	0.053de	7.63ab	9.52abc	4.71b	5.10a	0.043cd	0.069d	7.55cd	7.90e
	At flowering+15 days	4.56a	5.22a	0.048b-e	0.145a	8.00ab	10.00ab	4.75b	5.25a	0.097a	0.141a	7.50cd	8.13de
Calcium chloride	At flowering	4.21a	5.33a	0.033de	0.043de	6.75b	9.00bc	4.65b	5.13a	0.051cd	0.076cd	7.25d	8.04de
	After 15 days	4.96a	5.61a	0.034de	0.045de	8.50ab	9.17bc	5.27a	5.42a	0.048cd	0.076cd	8.50bc	8.75bcd
	At flowering+15 days	4.99a	5.24a	0.032de	0.041e	9.00a	9.08bc	5.32a	5.56a	0.037d	0.069d	9.58a	9.65a
Calcium carbonate	At flowering	4.79a	5.24a	0.075a	0.093b	6.75b	8.42c	5.20a	5.45a	0.080b	0.104bc	8.00bcd	8.36cde
	After 15 days	4.96a	5.43a	0.051bcd	0.057cde	7.99ab	9.33bc	5.23a	5.42a	0.053cd	0.074cd	8.75ab	9.00abc
	At flowering+15 days	4.92a	5.32a	0.032de	0.045de	7.98ab	10.08ab	5.24a	5.40a	0.060c	0.088c	8.52bc	8.75bcd
Calcium chelate	At flowering	4.86a	5.14a	0.066ab	0.134a	8.45ab	8.92bc	5.13a	5.27a	0.100a	0.137a	8.12bcd	8.50cde
	After 15 days	4.94a	5.27a	0.037cde	0.062cd	7.26ab	10.85a	5.19a	5.34a	0.043cd	0.069d	8.43bc	9.00abc
	At flowering+15 days	4.85a	5.20a	0.054bc	0.073c	7.08b	10.17ab	5.21a	5.38a	0.059c	0.084c	8.72ab	9.33ab

***Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.**

CONCLUSION

Spraying tomato plants grown under low tunnels in calcareous soil with Ca in different sources had positive effects on both marketable yield and blossom-end rot incidence, total yield, marketability% and BER%. But it had slight effect on fruit quality after 10 days of storage period compared to control. Application times of Ca did not gave significant effect, almost on all the previous determined parameters.

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تأثير مصادر ومواعيد اضافه الكالسيوم على المحصول القابل للتسويق والإصابة بعفن الطرف الزهري وجوده الثمار في الطماطم المنزرعة فى الارض الجيرية

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اجريت تجربتان حقليتان بالمزرعة البحثية لكليه العلوم الزراعية البيئية بالعريش جامعه قناه السويس خلال موسمي الشتاء ٢٠١١/٢٠١٢و٢٠١٢/٢٠١٣ بهدف دراسة تأثير رش محصول الطماطم صنف (جي اس ١٢) بمصادر مختلفة من الكالسيوم (كلوريد كالسيوم, كربونات كالسيوم, شيلات كالسيوم وكنترول (بدون كالسيوم) ومواعيد اضافه مختلفة (الرش مره واحده عند اكتمال التزهير, الرش مرة واحده بعد ١٥ يوم من الرشة الاولى والرش مرتين عند اكتمال التزهير+ بعد ١٥ يوم) على المحصول القابل للتسويق والغير قابل للتسويق (الثمار المصابة بعفن الثمرة الزهري) وجوده الثمار بعد ١٠ ايام من بداية فتره التخزين, وتم زراعه نباتات الطماطم تحت الانفاق البلاستيكية المنخفضة. تشير النتائج ان الرش بمصادر الكالسيوم كلوريد كالسيوم او كربونات كالسيوم الى زياده المحصول القابل للتسويق/ فدان, واطاله فتره التخزين معبرا عنها بالنقص في الفقد في الوزن وزياده صلابه الثمار. ادت اضافه كلوريد الكالسيوم للحصول على اقل محتوى للثمار من الليكوبين خلال الموسمين. كما توضح النتائج انه لم تعطى مواعيد اضافه الكالسيوم تأثير معنوي على كلا من المحصول القابل, الغير قابل للتسويق, نسبه المحصول القابل للتسويق من المحصول الكلى, نسبه الثمار المصابة بعفن الثمرة الزهري بالإضافة الى قيمه pH ونسبه المواد الصلبة الذائبة الكلية بالثمار. اعطت معامله الرش عند الازهار الكامل + بعد ١٥ يوم للحصول على اعلى محتوى للثمار من فيتامين ج, بينما ادى الرش بعد ١٥ يوم من الازهار لنقص محتوى الثمار من الليكوبين. اعطت جميع معاملات التفاعل مع الكنترول (بدون كالسيوم) خلال الموسم الثاني الى نقص كلا من المحصول القابل للتسويق ونسبته من المحصول الكلى, بينما ادت الى زياده المحصول الغير قابل للتسويق, نسبه الثمار المصابة بعفن الثمرة الزهري, الفقد فى الوزن وكذلك نسبه المواد الصلبة الذائبة الكلية. وعليه يوصى البحث برش نباتات الطماطم المنزرعة تحت الانفاق البلاستيكية المنخفضة في الارض الجيرية باي مصدر من مصادر الكالسيوم لتأثيرها الإيجابي على كميه المحصول الكلى القابل للتسويق والإصابة بعفن الطرف الزهري وعلى جوده الثمار بعد عشره ايام من التخزين مقارنه بالكنترول.