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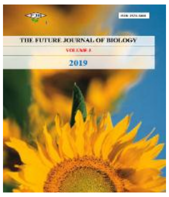

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IMPROVEMENT, PRODUCTIVITY, FRUIT QUALITY AND STORABILITY OF CHERRY TOMATO VIA FOLIAR APPLICATION WITH DIFFERENT CALCIUM SOURCES AND SOME MICRONUTRIENTS

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ABSTRACT: Two plastic house and Handling Lab. experiments were concluded in 2018/2019 and 2019/2020 seasons at the Experimental Farm of El-Kassasein, Res. Station, Hort, Res. Inst., Agric. Center, Ismailia Governorate, Egypt, it aims to study the effect of different sources of calcium, some micronutrients (boron and molybdenum) and their interaction as foliar spray on growth, yield, fruit quality and storability of tomato cherry under sandy soil conditions using drip irrigation system. The obtained result show that, the interaction between spraying plants with calcium citrate (Ca-Cit) at 2 % and boron (B) at 25 ppm recorded the highest value of dry weight of shoots / plant , average fruit weight , yield / plant and total yield / m^2 , lycopen and vitamin C content in fruits at harvest time in both seasons, where foliar application by the interaction between calcium chloride ($CaCl_2$) at 2% and B at 25 ppm had significantly increased number of fruits / plant, DM%, fruit firmness, TSS, Ca and B contents in fruits. The highest value of Mo concentration in fruits were recorded with the interaction between Ca-citrate and Mo at 5 ppm. The increases in total yield / m^2 were about 2.033 and 2.642 kg for the interaction between spraying with Ca-Cit at 2 % and B at 25 ppm, 1.639 and 1.474 kg for the interaction between calcium chloride at 2% and B at 25 ppm and 1.434 and 1.436 kg for the interaction between calcium tartrate at 2% and B at 25 ppm over the unsprayed plants in the 1st and 2nd seasons, respectively. As for storability of fruits which stored in carton box at 8°C and 90-95 % RH, fresh weight loss (%) and TSS in fruits increased, whereas fruit firmness, titratable acidity and vitamin C in fruits decreased with prolonging cold storage periods for all treatments. Storage of fruits produced from plants which sprayed with Ca Cl_2 at 2 % and B at 25 ppm pre harvested gave the highest values of TSS, fruit firmness and gave lowest values of titratable acidity, whereas the interaction between Ca-Cit at 2 % and B at 25 ppm gave the highest value of vitamin C and lowest value of weight loss percentage in fruit during storage period. The interaction between foliar application of the calcium citrate or calcium chloride 2 % and boron 25 ppm is recommended for high yield, best fruit quality and prolonged storability of cherry tomato.

Key words: Cherry tomato, *Solanum lycopersicum* var. cerasiforme, Ca, B, Mo, growth, yield, fruit quality and storability.

INTRODUCTION

Cherry tomato is a smaller garden variety of tomato. Cherry tomatoes range in size from a thumb tip up to the size of a golf ball, and can range from being spherical to slightly oblong in shape. The cherry tomato is regarded as a botanical variety of the cultivated tomato, *Solanum lycopersicum* var. cerasiforme or *Lycopersicon esculentum* var. cerasiforme. In addition to its economic importance, cherry tomato consumption has recently been demonstrated to be beneficial to human health, because of its content of phytochemicals such as lycopene, β-carotene, flavonoids, vitamin C and many essential nutrients (**Beutner *et al.*, 2001**). This composition explains the high antioxidant capacity in both fresh and processed tomatoes, associating the fruit with lower rates of certain types of cancer and cardiovascular disease (**Rao and Aggarwal, 2000**).

Calcium is an important nutrient that plays a key role in the structure of cell walls and cell membranes, fruit growth, and development, as well as general fruit quality (**Kadir, 2004**).

Micronutrients such as B and Mo play an important role in not only plant growth but also different metabolic processes in the plant body such as photosynthesis, enzyme activity, respiration, cell development, nitrogen fixation and hormone synthesis, but they are required in small quantity for the plant body (**Mengel *et al*., 2001**). Micronutrient deficiencies are one of the major limiting factors for crop production and quality of crops. Furthermore, the application of micronutrients increases the efficiency of macronutrients.

Boron plays an essential role in the growth and development of new cells in the meristematic region of plants. Boron is necessary for cell wall formation, development of fruit and seed. It helps in pollen formation, pollination and flowering of plants (**Malek and Rahim, 2011**) The primary role of boron in plants is to improve solubility and metabolism of Ca and its mobility and also helps in the absorption of nitrogen (**Pandav *et al*., 2016**). It also involves in metabolism, uptake of calcium and transport of carbohydrates, nucleic acid synthesis, root elongation, photosynthetic activities and water absorption in plant parts (**Islam *et al*., 2016**). In addition, B may function in cell –wall metabolism by maintaining calcium pectate associations in tomatoes (**Davis *et al*., 2003**).

Molybdenum is required for the assimilation of nitrates, as well as, for the fixation of atmospheric nitrogen. It helps in protein synthesis and sulphur metabolism. Low and adequate levels of molybdenum has a positive effect on carotenoides formation. It also helps in absorption and translocation of iron in plants. Deficiency symptoms resemble those of nitrogen because the function of molybdenum is to assimilate nitrogen in the plant. Molybdenum deficiency can be common in nitrogen-fixing legumes **(Sidhu *et al*., 2019).**

Both B and Ca play a vital role in cell -wall synthesis and structure by cross-linking pectic compounds (**Loomis and Durst, 1992**). Ca-interacts with B, which has a stabilizing influence on Ca complexes in the middle lamella of fresh-market tomatoes (**Huang and Snapp, 2004**). As cell compactness increases, so does shelf life; as a result, tomatoes retain their firmness longer. The most important factor in postharvest quality is firmness, which can maintain tomato quality and prolong shelf life by increasing the tomato’s cell -wall thickness or cell compactness**.**

Tomato fruits after harvesting commonly encourtered postharvest problems, such as strong physiological activities, quality degradation, shriveling associated to rapid loss of weight, nutritive components as well as fast physical decay and rapid senescence. Therefore, maintaining freshness of fruits has been a challenge in keeping its postharvest quality such as reducing water loss, delaying softening and extending shelf life period (**Xie *et al.*, 2004**).

Weight loss percentage and total soluble solids of cherry tomato increased significantly with the prolongation of the storage period, fruit firmness and titratable acidity were decreased ***(*Atress and Rashid, 2011**). Continues increase in weight loss % with the prolongation of storage period, while cherry tomato vitamin C was decreased ***(*Raafat *et al.*, 2016**). A considerable increase in weight loss percentage of stored cherry tomato fruits when the storage period prolonged, while, fruit firmness was decreased as the duration of storage is increased **(Abdullah and Ibrahim, 2018**).

In this regard, **Gad El-Rab (2013**) concluded that fresh-cut sweet pepper dipped in 3% citric acid + 1% calcium lactate reduced weight loss, maintained fruit texture and contain high content of ascorbic acid as compared with untreated control.

The scope of the present investigation is to detected the effectiveness of the foliar application of different source calcium and some micronutrients in enhancing the growth, yield, fruit quality and storability of cherry tomato under sandy soil conditions.

MATERIALS AND METHODS

Experiment location

The experiment was conducted in plastic house (9 m width x 40 m long) during 2018/2019 and 2019/2020 growing seasons at El-Kassasein, Hort. Res. Station, Hort. Res. Inst. Agric. Res. center, Ismailia Governorate and Handling Lab., Hort. Dept., Fac. Agric. Zagazig University, Egypt. It aims to study the effect of different source of calcium, some micronutrients and their interactions as foliar spray on growth, yield, fruit quality and storability of cherry tomato plants grown in sandy soil and using irrigation system.

Experiment planning

This experiment consisted twelve treatments combinations including four foliar application of different sources calcium (Ca-Cit, $CaCl_2$, Ca Tar at

2% each), with control (water spray) and the three treatments foliar spray were two micronutrients (B at 25 ppm and Mo at 5 ppm) and control treatment which was water spray.

These treatments were arranged in a split plot in a randomized complete block design with three replicates. Different sources of calcium were randomly arranged in the main plots and micronutrients treatments were randomly distributed in the sub plots.

The total area of plastic house was 360 m^2 (40 m long and 9 m width). The plastic house contained 6 rows (36 m long and 1.5 m width) each row divided into six equal divisions (6 m long and 1.5 m width) and each replicate equal 12 plots.

The experimental unit area was 9 m^2. It contained one dripper line 6 m long and 1.5 m width. Each plot included 12 plants. The total number of plants / plastic house were about 432 plants (1.33 plants/m^2).

Cherry tomato seeds of *Red* cherry cultivar produced from Hort. Res. Inst., Egypt were sown in nursery on 15th and 20th August in the two seasons and were transplanted on 15th and 20 Sept. in 2018 and 2019 seasons, respectively**.**

Preparation of sources calcium, micronutrients and application

Calcium citrate $Ca_3(C_6H_5O_7)_2$, calcium chloride ($CaCl_2$) and calcium tartrate ($CaC_4H_4O_6$) were applied at a rate 2 % each, B at 25 ppm was form (H_2BO_3) and Mo at 5 ppm was ammonium molybdate $(NH4)_6Mo_7O_{24}.4H_2O$. All compound were obtained from central lab of organic Agric., ARC, Egypt.

All treatment foliar application were sprayed five times at 30, 45, 60, 75 and 90 days after transplanting**.** The other normal agricultural treatments for growing cherry tomato plants were practiced.

Data recorded

1- Shoot dry weight / plant: A random sample of three plants from each plot was randomly taken at 105 days after transplanting in the two growing seasons for measuring the shoot dry weight/plant (g) was measured after dried fresh shoot / plant at 70 ºC till constant weight.

2- Yield and yield components: Fruits of each plot were harvested at the proper maturity stage, counted and weighed in each harvest and yield/plant, total yield/ m^2(kg) (360m^2= 9m width x 40 m length), average fruit weight and number of fruits/ plant were determined.

3- **Fruit quality:** Fruit quality was measured in the mid of the harvesting season as follows:

- Dry matter content: One hundred gram of fresh fruits was oven dried at 105°C till constant weight and DM% was calculated

- Fruit firmness: Fruit firmness of each individual cherry tomato fruits was measured at two points of the equatorial region by using a pressure tester 8-mm plunger. The firmness of the flesh was expressed as (g/cm^3).

- Total soluble solids (TSS): The percentage of total soluble solids (TSS) was determined by measuring the refractive index of fruit juice by a hand refractometer and the results were expressed as a percentage.

- Lycopine contents (**mg/100 g FW)**: the fruits samples were extracted with hexane: ethanol: acetone (2:1:1) (v/v) mixture following the method of **Sharma and Le Maquer (1996**).

- Ascorbic acid content (Vitamin C): it was determined using the dye 2, 6-dichloro-phenol indophenols method (**A.O.A.C., 2000**).

- Calcium (%) was determined in fruits according to **Cottenie *et al.* (1982**), while B and Mo concentrations were determined in the fruits by using Atomic Absorption/Flame Spectrophotometer AA-646 according to **Allen *et al.* (1997**).

Storage experiment

This experiment was conducted to study the effect of some nutritional elements in comparison with control treatment on keeping quality of cherry tomato fruits during cold storage. In this experiment, cherry tomato fruits which obtained from the plastic house experiment were harvested at turning stage (50% red colour) on 11th and 13th of January in the first and second seasons, respectively then transported soon to the Handling Lab., Hort. Dept., Fac. Agric., Zagazig University, Egypt, within two hours after harvesting. Fruits of the same size (20-25mm in diameter), shape and free from visual damage or defects, washed initially with water, and allowed to dry for 1hour at room temperature. After drying fruits were packed in punnets each punnet contained about 250 g. of cherry tomatoes repressed on replicate. Nine punntes for each treatment were prepared then placed in carton box and storage at 8°C and 90-95 % RH. Three replicates (punnets) were randomly taken from each treatment every 10days (10, 20, and 30 days). The number of punnets required for this experiment were 1 punnet x 3 replicate = 3 for each storing period x 3 storing periods = 9 x 12 treatements = 108 punnets.

These treatments were arranged in a randomized complete design. Samples were evaluated for the changes in the quality parameters during storage as follows:

Weight loss percentage: Weight loss percentage of cherry tomatoes fruits were estimated according to the following equation:

$$\text{Weight loss \%} = \frac{\text{Initial fruit weight – fruit weight of sampling date}}{\text{Initial fruit weight}} \times 100$$

Fruit firmness, total soluble solids (TSS) and ascorbic acid content (vitamin C): were determined at 10, 20 and 30 days from cold storage by using the same methods as described above in fruit quality.

Titratable acidity (TA): The TA was measured by titration of 10 grams of fruit juice in 20 ml distilled water with a solution of 0.1 N NaOH using phenolphthalein as indicator. The titratable acidity % was expressed as citric acid according to the **A.O.A.C. (2000).**

Statistical analysis

Collected data were subjected to proper statistical analysis of variance according to **Snedecor and Cochran (1980)** and the differences among treatments were compared using LSD at 5 % levels.

RESULTS AND DISCUSSION

Dry weight of shoots / plant

Effect of calcium sources

Data in table 1 show that Ca-Cit at 2 % significantly increased dry weight of shoots/ plant compared to other treatments at 105 days after transplanting (DAT) in both seasons. The increases in total dry weight were about 150.63 and 168.49 g for Ca-Cit at 2%, 110.18 and 107.63 for $CaCl_2$ at 2 % and 33.39 and 31.96 for ca-tar. At 2 % over the control treatment (spraying with water) in the 1st and 2nd seasons, respectively.

The important role of Ca in plant growth is emphasized in many ways. It can be indicated most easily by increased leakage of low molecular-weight solutes from cells of Ca-deficient tissues in seriously deficient plants, by a general disintegration of membrane structures, and by a loss of cell segmentation (**Van Goer, 1996**).

Effect of some micronutrients

Foliar spray with B at 25 ppm and Mo at 5 ppm increased dry weight of shoots / plant at 105 DAT compared control, and B at 25 ppm gave the highest values in both seasons (Table 1). The increases in total dry weight were about 75 and 74.19 g for B at 25 ppm and 33.12 and 29.18 g / plant for Mo at 5 ppm over the control in the 1st and 2nd seasons, respectively.

The primary role of boron in plants is to improve solubility and metabolism of Ca and its mobility and also helps in the absorption of nitrogen **(Pandav *et al.*, 2016)**. It also involves in metabolism and transport of carbohydrates, nucleic acid synthesis, root elongation, photosynthetic activities and water absorption in plant parts and then, enhanced fresh and dry weight (**Islam *et al*., 2016)**.

Effect of the interaction

The interaction between foliar spray with Ca-Cit, $CaCl_2$ and calcium tartrate Ca-Tar and foliar spray with B or Mo increased dry weight of shoots/ plant at 105 DAT in both seasons, compared to spraying with water (Table 1). The interaction between foliar application with Ca-Cit at 2 % and B at 25 ppm, followed by the interaction between $CaCl_2$ at 2 %+ B at 25 ppm gave the highest values of dry weight of shoots / plant in both seasons.

The increases in dry weight of shoots were about 228.08 and 243.58 g for the interaction between Ca-Cit at 2 % and B at 25 ppm and 218.71 and 223.6 g for the interaction between $CaCl_2$ at 2 % and B at 25 ppm over the control (spraying with water) in the 1st and 2nd, seasons, respectively.

In general, spraying tomato cherry with Ca Cit and B or $CaCl_2$ and B increased dry weight of shoots / plant compared to spraying with calcium citrate, calcium chloride only.

Both calcium and boron are required for the growth and development of plants **(Bose and Tripathi ,1996)**. Boron increased plant height and the number of branches of tomato plant by promoting root growth, which enhances nutrient absorption **(Sathya *et al.*, 2010**). Deficiency of calcium and boron decreases plant height by decreasing mitotic activity in the terminal meristem (**Nelson and Niedziela, 1998**). Thus, the application of calcium chloride and borax increases plant height **(Dole and Wilkins 2005).** Since boron enhances calcium metabolism, especially in the cell wall **(Blevins and Lukaszewski 1998).**

These results are agreements with those obtained with **Abdur and ul Haq (2012), Ekinci *et al*. (2015) and Fouda (2017)** on tomato.

Table 1. Effect of foliar application with calcium sources, some microelements and their interaction on dry weight of shoot/ plant of cherry tomato at 105 days after transplanting during 2018/2019 and 2019/2020 seasons

Calcium sources	**Microelements**			
	Control	**B at 25 ppm**	**Mo at 5 ppm**	**Mean (Ca)**
		2018/2019 season		
Control	158.61	225.30	197.30	**193.74**
Ca citrate at 2%	312.85	386.69	333.62	**344.39**
Ca chloride at 2%	237.56	377.32	296.88	**303.92**
Ca tartrate at 2%	215.97	235.71	229.70	**227.13**
Mean (Mico)	**231.25**	**306.25**	**264.37**	**---**
LSD at 0.05 level	**Ca= 5.99**	**Micro= 4.49**	**Ca x Micro=8.99**	
		2019/2020 season		
Control	155.40	230.60	199.73	195.24
Ca citrate at 2%	341.80	398.98	350.40	363.73
Ca chloride at 2%	240.00	379.00	289.60	302.87
Ca tartrate at 2%	214.00	239.40	228.20	227.20
Mean	237.80	311.99	266.98	
LSD at 0.05 level	**Ca=3.29**	**Micro= 2.47**	**Ca x Micro=4.94**	

Yield and its components

Effect of calcium sources

The obtained results in Tables (2,3, 4 and 5) indicate that spraying with Ca-Cit at 2 %, $CaCl_2$ at 2 % and Ca-Tar at 2 % increased average fruit weight, yield / plant and total yield /m^2 compared to control in both seasons, and Ca -Cit at 2 % gave the highest value, followed by Ca Cl_2 at 2 % compared to other treatments. As for number of fruits/ plant, $CaCl_2$ at 2 % increased number of fruits/ plant followed by Ca-Tar. at 2 %. The increases in total yield /m^2, were about 1.367 and 1.501 kg for Ca-Cit. at 2 %, 1.113 and 1.071 kg for $CaCl_2$ and 0.786 and 0.944 kg for Ca.Tar at 2% over the control in the 1st and 2nd seasons, respectively.

These results are in line with **Ekinci *et al.* (2015)** they indicated that spraying tomato plants with Ca was the more effect than unsprayed plants.

Effect of some microelements

Data in Tables (2,3,4 and 5) reported that foliar spray with B at 25 ppm and Mo at 5 ppm increased average fruit weight, number of fruits / plant, yield / plant and total yield / m^2. compared to control and B at 25 ppm gave the highest values in both seasons. The increases in total yield / m^2, were about 0.757 and 0.692 kg for B at 25 ppm and 0.455 and 0.376 kg for Mo at 5 ppm over the control in the 1st and 2nd seasons, respectively.

The application of boron enhances fruit set (**Desouky *et al.* 2009**) by delaying abscission of flowers**.** Thus, it is likely that the higher number of flowers per cluster could be due to sufficient levels of carbohydrates available for flower formation and fruit set in tomato.

Effect of the interaction

Data in Tables 2,3,4 and 5 show that foliar application of cherry tomato with some calcium sources and some microelements had significant effect on average fruit weight, number of fruits/ plant, yield / plant and total yield / m^2, average fruit weight and number of fruit / plant. The interaction between foliar spray with Ca-Cit at 2 % and B at 25 ppm or $CaCl_2$ at 2 % and B at 25 ppm gave the highest values of average fruit weight and number of fruits / plant, respectively. Respecting yield / plant and total yield / m^2, the interaction between spraying with Ca-Cit at 2 % and B at 25 ppm, Ca-Cit at 2 % and Mo at 5 ppm and $CaCl_2$ at 2 % and B at 25 ppm gave the highest values of yield / plant and total yield / m^2 in both seasons.

The increases in total yield / m^2 were about 2.033 and 2.342 kg for the interaction between spraying with Ca-Cit at 2 % and B at 25 ppm, 1.639 and 1.474 kg for the interaction between calcium chloride at 2% and B at 25 ppm and 1.434 and 1.436 kg for the interaction between calcium tartrate at 2% and B at 25 ppm over the unsprayed plants in the 1st and 2nd seasons, respectively.

Table 2. Effect of foliar application with calcium sources, some microelements and their interaction on average fruit weight (g) of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	Microelements			
	Control	B at 25 ppm	Mo at 5 ppm	Mean (Ca)
	2018/2019 season			
Control	16.96	20.28	18.04	**18.42**
Ca citrate at 2%	23.70	28.81	26.11	**26.20**
Ca chloride at 2%	21.43	22.35	22.27	**22.02**
Ca tartrate at 2%	17.62	21.58	20.55	**19.92**
Mean (Mico)	**19.92**	**23.25**	**21.74**	--
LSD at 0.05 level	**Ca= 0.98**	**Micro=0.72**	**Ca x Micro=1.47**	
	2019/2020 season			
Control	16.98	20.10	18.14	**18.41**
Ca citrate at 2%	24.34	28.50	25.04	**25.95**
Ca chloride at 2%	21.22	21.96	21.16	**21.44**
Ca tartrate at 2%	17.80	21.77	21.82	**20.46**
Mean	**20.09**	**23.08**	**21.54**	--
LSD at 0.05 level	**Ca= 1.09**	**Micro=0.81**	**Ca x Micro=1.63**	

Table 3. Effect of foliar application with calcium sources, some microelements and their interaction on number of fruits/ plant of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	Microelements			
	Control	B at 25 ppm	Mo at 5 ppm	Mean (Ca)
	2018/2019 season			
Control	92.43	97.39	94.37	**94.73**
Ca citrate at 2%	100.55	107.46	109.88	**105.96**
Ca chloride at 2%	110.63	125.27	116.03	**117.31**
Ca tartrate at 2%	108.91	122.61	119.31	**116.94**
Mean (Mico)	**103.13**	**113.18**	**109.90**	--
LSD at 0.05 level	**Ca= 1.37**	**Micro=1.04**	**Ca x Micro=2.09**	
	2019/2020 season			
Control	90.65	94.89	92.05	**92.53**
Ca citrate at 2%	99.53	115.78	110.96	**108.76**
Ca chloride at 2%	112.42	120.56	118.03	**117.00**
Ca tartrate at 2%	115.00	120.31	118.21	**117.84**
Mean	**104.40**	**112.89**	**109.81**	--
LSD at 0.05 level	**Ca= 1.81**	**Micro=1.35**	**Ca x Micro=2.72**	

The stimulative effect of the interaction between Ca-Cit and B or $CaCl_2$ and B on total yield/ m^2 may be due to that Ca-Cit and B or $CaCl_2$ and B increased dry weight of shoots / plant of tomato cherry (Table 1), also Ca-Cit and B increased average fruit weight (Table 2) and $CaCl_2$ + B increased average number of fruits / plant (Table 3). There were positive correlation among dry weight of shoots/ plant, number of fruits/ plant and total yield/ m^2 whereas, there was negative correlation between number of fruits/ plant and average fruit weight. Cherry tomato productivity is directly related to the number of fruits/ plant (**Sari *et al.*, 2017**).

Table 4. Effect of foliar application with calcium sources, some microelements and their interaction on yield / plant (kg) of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	**Microelements**			
	Control	**B at 25 ppm**	**Mo at 5 ppm**	**Mean (Ca)**
	2018/2019 season			
Control	1.568	1.975	1.702	**1.748**
Ca citrate at 2%	2.383	3.096	2.869	**2.783**
Ca chloride at 2%	2.371	2.800	2.584	**2.585**
Ca tartrate at 2%	1.919	2.646	2.452	**2.339**
Mean (Mico)	**2.060**	**2.629**	**2.402**	**--**
LSD at 0.05 level	**Ca= 0.091**	**Micro=0.068**	**Ca x Micro=0.136**	
	2019/2020 season			
Control	1.539	1.907	1.670	**1.705**
Ca citrate at 2%	2.423	3.300	2.778	**2.834**
Ca chloride at 2%	2.386	2.647	2.498	**2.510**
Ca tartrate at 2%	2.047	2.619	2.579	**2.415**
Mean	**2.099**	**2.618**	**2.381**	**--**
LSD at 0.05 level	**Ca= 0.115**	**Micro=0.87**	**Ca x Micro=0.172**	

Table 5. Effect of foliar application with calcium sources, some microelements and their interaction on yield/ m^2 (kg) of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	**Microelements**			
	Control	**B at 25 ppm**	**Mo at 5 ppm**	**Mean (Ca)**
	2018/2019 season			
Control	2.085	2.627	2.264	**2.325**
Ca citrate at 2%	3.169	4.118	3.816	**3.701**
Ca chloride at 2%	3.153	3.724	3.437	**3.438**
Ca tartrate at 2%	2.552	3.519	3.261	**3.111**
Mean (Mico)	**2.740**	**3.497**	**3.195**	**---**
LSD at 0.05 level	**Ca = 0.121**	**Micro =0.090**	**Ca x Micro =0.180**	
	2019/2020 season			
Control	2.047	2.537	2.221	**2.268**
Ca citrate at 2%	3.222	4.389	3.695	**3.769**
Ca chloride at 2%	3.173	3.521	3.322	**3.339**
Ca tartrate at 2%	2.723	3.483	3.431	**3.212**
Mean	**2.791**	**3.483**	**3.167**	**--**
LSD at 0.05 level	**Ca = 0.152**	**Micro =0.115**	**Ca x Micro =0.228**	

Both Ca and B are required for decreasing the abscission of flowers and fruits **(Smit and Combrink 2005).** Also, Ca and B are considered to be vital elements in the primary walls, cell membranes, fruit growth, and development of plant cells (**Pilbeam and Morely, 2007**).

Results are harmony with those reported with **Abdur and ul Haq** (**2012**), **Petchhong & Khurnpoon (2017) and Tejashvini *et al.* (2018)** they showed that spraying tomato cherry with the calcium-boron had the percentage of fruit set, number of fruit per inflorescence, number of fruit per plant and fruit size higher than the control (non-sprayed).

Fruit quality

Effect of calcium sources

Spraying with $CaCl_2$ at 2 % increased DM%, TSS, fruit firmness, concentrations of Ca, B and Mo in fruits with no significant differences with Ca-Cit at 2 % as for fruit firmness (Tables 6 to 13), whereas spraying with Ca-Cit at 2 % increased lycopine and Vit. C in fruits with no significant differences with $CaCl_2$ at 2% and Ca-tar at 2 % in the 2nd seasons regarding to lycopine and $CaCl_2$ at 2 % in the 1st season with respect to Vit C (Tables 9 and 10). In general, foliar spray with Ca-Cit, $CaCl_2$ and Ca-Tar. increased DM, TSS, Vit. C and fruit firmness compared to control.

In this regard, **Abd-El-Hamied and Abd El-Hady** (**2018**) showed that spraying tomato plants with calcium at 3% increased lycopene and Ca contents in fruits contents in fruits than unsprayed.

Effect of some microelements

Spraying with B at 25 ppm increased DM, fruit firmness, lycopine, TSS and Vit. C, Ca and B concentrations in fruits (Tables 6 to 12) compared to Mo at 5 ppm in both seasons, whereas Mo at 5 ppm increased Mo concentration in fruits compared to control or B at 25 ppm (Table 13).

These results are harmony with those obtained with **Mallick *et al*. (2021)**. They reported that application of B increased fruit quality of tomato such as increased the content of acidity, lycopine and vitamin C than untreated plants. Also, **Davis *et al.* (2003)**. They indicate that spraying tomato plants with boron at 1.87 mg/·L significantly enhanced the contents of ca and B in fruits than unsprayed plants also, **Islam *et al*. (2016)** on cherry tomato reported that spraying tomato with 4.85 mM B from boric acid ($H_3 BO_3$) increased the content of B in fruits than unsprayed.

Effect of the interaction

The obtained results in Tables 6, 7, 8, 11 and 12 indicate that the interaction between $CaCl_2$ at 2 % and B at 25 ppm increased DM%, firmness, TSS (brix), Ca and B concentrations in fruits in tomato cherry fruits compared to the other treatments and control.

The interaction between Ca-Tar at 2% and B at 25 ppm increased lycopine content in fruits (Table 9). While, the interaction between Ca-Cit at 2 % and B at 25 ppm or the interaction between Ca-Cit at 2 % and Mo at 5 ppm gave the highest value of vitamin C content in fruits in both seasons (Table (10). On the other hand, the interaction between $CaCl_2$ and Mo at 5 ppm increased Mo concentration in fruit (Table 13), In general, foliar application with calcium sources and microelements increased fruit quality of tomato cherry (DM%, firmness, TSS, lycopen and vitamin C) compared to control (spraying with water).

The stimulative effect of the interaction between $CaCl_2$ and B on DM%, fruit firmness and TSS may be due to that $CaCl_2$ increased Ca content in tomato cherry fruits (Table 11). There were positive correlation among DM%, fruit firmness and TSS in fruits.

Tomato fruits that take up B and Ca have better firmness than the control because these treatments may lead to pectin bonding to stabilize cell -wall structure. Ca-treated strawberries contain fewer soluble solids and higher acidity than the control (**Singh *et al*., 2007**). Also, Cherry tomatoes treated with B + Ca had more vitamin C than the control fruit due to improved membrane integrity, slowed biosynthesis, and reduced respiration (**Islam *et al*., 2018**). However, **Ekinci *et al.* (2015) found that** translocations of Ca and B from leaf to fruit were also affected positively by the Ca and B applications

Obtained results are in a good line with those reported by **Abdur and ul Haq, (2012)** and **Petchhong and Khurnpoon (2017)** they showed that spraying tomato cherry with the calcium-boron had the higher in fruit firmness, vitamin c content and titratable acidity (TA) content than the control treatment.

Table 6. Effect of foliar application with calcium sources, some microelements and their interaction on dry matter (%) in fruits of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	Microelements			
	Control	B at 25 ppm	Mo at 5 ppm	Mean (Ca)
	2018/2019 season			
Control	6.61	7.68	6.88	**7.05**
Ca citrate at 2%	8.09	8.86	7.75	**8.23**
Ca chloride at 2%	8.99	9.72	8.99	**9.23**
Ca tartrate at 2%	7.60	8.26	8.32	**8.06**
Mean (Mico)	**7.82**	**8.63**	**7.98**	
LSD at 0.05 level	**Ca= 0.36**	**Micro=0.27**	**Ca x Micro=0.54**	
	2019/2020 season			
Control	6.36	7.59	6.92	**6.95**
Ca citrate at 2%	9.01	8.51	8.64	**8.72**
Ca chloride at 2%	8.97	10.13	9.06	**9.38**
Ca tartrate at 2%	7.42	8.54	8.54	**8.16**
Mean	**7.94**	**8.69**	**8.29**	
LSD at 0.05 level	**Ca= 0.45**	**Micro=0.33**	**Ca x Micro=0.67**	

Table 7. Effect of foliar application with calcium sources, some microelements and their interaction on firmness (g/cm^3) in fruits of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	Microelements			
	Control	**B at 25 ppm**	**Mo at 5 ppm**	**Mean (Ca)**
	2018/2019 season			
Control	358.4	403.4	379.3	**380.3**
Ca citrate at 2%	444.1	458.0	465.2	**455.7**
Ca chloride at 2%	460.6	471.2	455.2	**462.3**
Ca tartrate at 2%	431.6	442.3	438.8	**437.5**
Mean (Mico)	**423.6**	**443.7**	**434.6**	--
LSD at 0.05 level	**Ca= 10.32**	**Micro=7.74**	**Ca x Micro=15.49**	
	2019/2020 season			
Control	344.1	402.2	364.9	**370.4**
Ca citrate at 2%	448.6	458.9	468.4	**458.6**
Ca chloride at 2%	463.8	484.6	455.9	**468.1**
Ca tartrate at 2%	436.8	446.9	441.6	**441.7**
Mean	**423.3**	**448.1**	**432.7**	---
LSD at 0.05 level	**Ca= 14.65**	**Micro=10.99**	**Ca x Micro=21.98**	

Table 8. Effect of foliar application with calcium sources, some microelements and their interaction on TSS (Brix) in fruits of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	Microelements			
	Control	**B at 25 ppm**	**Mo at 5 ppm**	**Mean (Ca)**
	2018/2019 season			
Control	7.21	8.43	8.41	**8.01**
Ca citrate at 2%	8.06	8.96	8.72	**8.58**
Ca chloride at 2%	8.00	9.16	9.08	**8.74**
Ca tartrate at 2%	7.94	8.71	8.35	**8.33**
Mean (Mico)	**7.80**	**8.81**	**8.64**	----
LSD at 0.05 level	**Ca= 0.06**	**Micro=0.04**	**Ca x Micro=0.09**	
	2019/2020 season			
Control	7.32	8.43	8.41	**8.05**
Ca citrate at 2%	8.06	8.96	8.72	**8.58**
Ca chloride at 2%	8.00	9.16	9.08	**8.74**
Ca tartrate at 2%	7.94	8.71	8.35	**8.33**
Mean	**7.83**	**8.81**	**8.64**	---
LSD at 0.05 level	**Ca= 0.35**	**Micro=0.26**	**Ca x Micro=0.52**	

Table 9. Effect of foliar application with calcium sources, some microelements and their interaction on lycopine content (mg /100 g fresh weight) in fruits of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	Microelements			
	Control	**B at 25 ppm**	**Mo at 5 ppm**	**Mean (Ca)**
	2018/2019 season			
Control	6.38	9.34	7.12	**7.61**
Ca citrate at 2%	9.91	10.30	8.95	**9.72**
Ca chloride at 2%	9.89	8.32	8.19	**8.80**
Ca tartrate at 2%	8.21	10.52	9.68	**9.47**
Mean (Mico)	**8.59**	**9.62**	**8.48**	
LSD at 0.05 level	**Ca= 0.37**	**Micro=0.27**	**Ca x Micro=055**	
	2019/2020 season			
Control	5.50	8.20	5.99	**6.56**
Ca citrate at 2%	8.69	8.79	7.98	**8.48**
Ca chloride at 2%	8.93	7.93	7.80	**8.22**
Ca tartrate at 2%	7.47	9.83	8.14	**8.48**
Mean	**7.64**	**8.68**	**7.47**	
LSD at 0.05 level	**Ca= 0.39**	**Micro=0.29**	**Ca x Micro=0.59**	

Table 10. Effect of foliar application with calcium sources, some microelements and their interaction on vitamin C (mg/100 ml juice) in fruits of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	Microelements			
	Control	**B at 25 ppm**	**Mo at 5 ppm**	**Mean (Ca)**
			2018/2019 season	
Control	16.02	16.64	16.33	**16.33**
Ca citrate at 2%	17.44	18.01	17.46	**17.63**
Ca chloride at 2%	17.15	17.31	17.15	**17.20**
Ca tartrate at 2%	16.74	17.01	16.96	**16.90**
Mean (Mico)	**16.83**	**17.24**	**16.97**	
LSD at 0.05 level	**Ca= 0.44**	**Micro=0.33**	**Ca x Micro=0.66**	
			2019/2020 season	
Control	16.21	16.81	16.49	**16.50**
Ca citrate at 2%	18.73	18.73	18.36	**18.60**
Ca chloride at 2%	17.55	18.02	17.72	**17.76**
Ca tartrate at 2%	16.50	17.19	17.07 e	**16.92**
Mean	**17.24**	**17.68**	**17.41**	
LSD at 0.05 level	**Ca= 0.39**	**Micro=0.29**	**Ca x Micro=0.59**	

Table 11. Effect of foliar application with calcium sources, some microelements and their interaction on calcium (%) in fruits of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	Microelements			
	Control	**B at 25 ppm**	**Mo at 5 ppm**	**Mean (Ca)**
			2018/2019 season	
Control	0.198	0.236	0.212	0.215
Ca citrate at 2%	0.238	0.249	0.267	0.251
Ca chloride at 2%	0.251	0.297	0.264	0.270
Ca tartrate at 2%	0.223	0.240	0.246	0.236
Mean (Mico)	0.227	0.255	0.247	
LSD at 0.05 level		**Ca= 0.012**	**Micro=0.008**	**Ca x Micro=0.018**
			2019/2020 season	
Control	0.182	0.229	0.207	0.206
Ca citrate at 2%	0.231	0.237	0.254	0.240
Ca chloride at 2%	0.242	0.282	0.252	0.258
Ca tartrate at 2%	0.212	0.231	0.235	0.226
Mean	**0.216**	**0.244**	**0.237**	
LSD at 0.05 level		**Ca= 0.009**	**Micro=0.007**	**Ca x Micro=0.015**

Table 12. Effect of foliar application with calcium sources, some microelements and their interaction on boron (ppm) in fruits of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	Microelements			
	Control	**B at 25 ppm**	**Mo at 5 ppm**	**Mean (Ca)**
			2018/2019 season	
Control	3.63	11.18	6.94	**7.25**
Ca citrate at 2%	6.76	16.36	8.18	**10.43**
Ca chloride at 2%	12.82	17.17	14.14	**14.71**
Ca tartrate at 2%	4.91	12.13	6.93	**7.99**
Mean (Mico)	**7.03**	**14.21**	**9.04**	
LSD at 0.05 level		**Ca= 0.39**	**Micro=0.29**	**Ca x Micro=0.58**
			2019/2020 season	
Control	3.42	10.79	6.49	**6.90**
Ca citrate at 2%	6.41	12.51	7.79	**8.90**
Ca chloride at 2%	13.89	16.28	14.22	**14.79**
Ca tartrate at 2%	4.72	12.01	6.84	**7.85**
Mean	**7.11**	**12.89**	**8.83B**	
LSD at 0.05 level		**Ca= 0.47**	**Micro=0.35**	**Ca x Micro=0.70**

Table 13. Effect of foliar application with calcium sources, some microelements and their interaction on molybdenum (ppm) in fruits of cherry tomato during 2018/2019 and 2019/2020 seasons

Calcium sources	**Microelements**			
	Control	**B at 25 ppm**	**Mo at 5 ppm**	**Mean (Ca)**
	2018/2019 season			
Control	1.80	2.10	2.27	**2.04**
Ca citrate at 2%	2.90	3.86	5.83	**4.19**
Ca chloride at 2%	4.98	5.53	7.57	**6.02**
Ca tartrate at 2%	2.25	2.32	3.55	**2.70**
Mean (Mico)	**2.98**	**3.45**	**4.79**	
LSD at 0.05 level	**Ca= 0.08**	**Micro=0.06**	**Ca x Micro=0.13**	
	2019/2020 season			
Control	1.89	2.05	2.09	**2.01**
Ca citrate at 2%	2.49	3.72	5.46	**3.88**
Ca chloride at 2%	4.74	5.42	7.92	**6.04**
Ca tartrate at 2%	2.17	2.19	3.42	**2.59**
Mean	**2.82**	**3.34**	**4.73**	
LSD at 0.05 level	**Ca= 0.15**	**Micro=0.11**	**Ca x Micro=0.23**	

From the foregoing results, it could be concluded that the interaction between calcium citrate or calcium chloride at 2 % each and B at 25 ppm as foliar application increased dry weight of shoots/ plant and total yield / m^2 of cherry tomato. The interaction between calcium citrate at 2 % and B at 25 ppm increased average fruit weight, lycopen and vitamin C content in fruits, whereas the interaction between calcium chloride at 2% and B at 25 ppm increased number of fruits/ plant, DM%, fruit firmness, TSS, concentrations of Ca and B in fruits.

Storability

Fresh weight loss percentage:

Fresh weight loss percentage (FWL) increased with the advanced of cold storage periods up to 30 days for all treatments (calcium sources and microelements) as shown in Table (14) pre- harvest foliar application of cherry tomato with Ca citrate at 2 % and B at 25 ppm decreased FWL of fruits at 10, 20 and 30 days of cold storage in both seasons. All treatments decreased FWL of fruits compared to control (spraying with water) and molybdenum at 5 ppm. This means that spraying cherry tomato plants with water as control and molybdenum at 5 ppm increased FWL during storage periods. At 30 days of cold storage periods, pre- harvest foliar spray with Ca citrate at 2 % and B at 25 ppm recorded minimum FWL % (2.74 and 2.69 %) in the 1st and 2nd seasons, respectively. In general, pre- harvest foliar spray with Ca citrate at 2% only or with B at 25 ppm decreased weight loss (%) in fruits during cold storage periods followed by foliar spray with $CaCl_2$ only or with B at 25 ppm.

Normally, the weight loss occurs during the fruit storage due to its respiratory processes, the transference of humidity and some processes of oxidation (**Sakaldas and Kaynas, 2010 and Techavuthiporn and Boonyaritthonghai, 2016**). These results are similar to those found by **Atress and Rashid (2011**) on cherry tomato, **Gad El-Rab (2013**) on sweet pepper and **Abdullah and Ibrahim (2018)** on cherry tomato.

Table 14. Effect of foliar application with calcium sources, some microelements and their combination preharvest on weight loss percentage of cherry tomato fruits during cold storage in 2018/2019 and 2019/2020 seasons

Treatments		**Weight loss %**				
		2018/2019 season				
Ca sources	**Microelements**	**Storage period in days (S)**				
		0	**10**	**20**	**30**	**Mean(S)**
Without	**Control (water)**	--	2.69	3.11	5.21	3.67
	B at 25 ppm	--	2.35	2.90	4.00	3.08
	Mo at 5 ppm	--	2.63	3.00	5.13	3.58
	Mean	--	2.56	3.00	4.78	**3.44**
Ca citrate at 2%	**Control (water)**	---	1.96	2.41	3.60	2.65
	B at 25 ppm	--	1.72	2.15	2.74	2.20
	Mo at 5 ppm	--	1.95	2.39	3.24	2.52
	Mean		1.88	2.32	3.19	**2.46**
Ca chloride at 2%	**Control (water)**	--	1.90	2.34	3.21	2.48
	B at 25 ppm	---	1.82	2.23	2.95	2.33
	Mo at 5 ppm	--	1.79	2.21	2.92	2.30
	Mean		1.84	2.26	3.03	**2.37**
Ca tartrate at 2%	**Control (water)**	---	2.19	2.73	3.85	2.92
	B at 25 ppm	--	2.03	2.62	3.73	2.79
	Mo at 5 ppm	--	2.17	2.71	3.81	2.89
	Mean		2.13	2.69	3.80	**2.87**
Mean(T)		--	**2.10**	**2.56**	**3.69**	---
Control		--	2.18	2.64	3.96	**2.93**
B at 25 ppm		---	1.98	2.47	3.35	**2.60**
Mo at 5 ppm		--	2.13	2.57	3.77	**2.82**
		2019/2020 season				
Without	**Control (water)**	--	2.43	3.04	5.19	3.55
	B at 25 ppm	---	2.26	2.82	3.97	3.01
	Mo at 5 ppm	--	2.37	2.94	5.10	3.47
	Mean	--	2.35	2.93	4.75	**3.35**
Ca citrate at 2%	**Control (water)**	--	1.85	2.38	3.57	2.60
	B at 25 ppm	---	1.56	2.11	2.69	2.12
	Mo at 5 ppm	--	1.81	2.36	3.22	2.46
	Mean	--	1.74	2.28	3.16	**2.39**
Ca chloride at 2%	**Control (water)**	--	1.78	2.30	3.19	2.42
	B at 25 ppm	---	1.66	2.22	2.92	2.26
	Mo at 5 ppm	--	1.63	2.19	2.88	2.23
	Mean	--	1.69	2.24	3.00	**2.31**
Ca tartrate at 2%	**Control (water)**	--	2.12	2.68	3.81	2.87
	B at 25 ppm	---	1.96	2.55	3.70	2.73
	Mo at 5 ppm	--	2.09	2.63	3.77	2.83
	Mean	--	2.06	2.62	3.76	**2.81**
Mean(T)		--	**1.96**	**2.51**	**3.66**	
Control		---	2.04	2.60	3.94	**2.86**
B at 25 ppm		--	1.86	2.42	3.32	**2.53**
Mo at 5 ppm		--	1.97	2.53	3.74	**2.75**

LSD at 5% season1 **Calcium sources (CaS)= 0.14** **Microelement (Mic)= 0.11** **CaS x Mic= 0.22** **Storage period (Sp) =0.10**

CaS x Sp = 0.21 **Mic x Sp=0.18** **CaS x Mic x Sp=0.36**

LSD at 5% season2 **Calcium sources (CaS)= 0.13** **Microelement (Mic)= 0.10** **CaS x Mic= 0.20** **Storage period (Sp) =0.09**

CaS x Sp = 0.19 **Mic x Sp= 0.17** **CaS x Mic x Sp=0.34**

Fruit firmness

Data in Table 15 show that pre-harvest foliar application with all calcium sources or microelements gave the highest values of fruit firmness compared to control (spraying with water) during cold storage periods (10, 20 and 30 days) in both seasons. Fruit firmness values decreased with advancing cold storage periods up to 30 days compared to zero time in both seasons. Spraying plants with $CaCl_2$ at 2% and B at 25 ppm increased fruit firmness in cold storage periods. In general spraying plants with Ca Cl_2 at 2 % only or with B at 25 ppm only increased fruit firmness compared to control and other treatments.

The postharvest storage of fruit is accompanied by loss of cell wall integrity due to breakdown of peptic substances, which led to an increase in soluble pectin and decrease in fruit firmness (**Mirdehghan *et al*., 2007**). Calcium maintain the cell wall structure in fruit by interacting with pectin in the cell wall to form calcium pectate which assists molecular bonding between constituents of cell wall (**Degrave *et al*., 2003**) also, the favorable effect of calcium citrate and/or calcium chloride could be due to the stabilization of the membrane systems through the formation of Ca-pectate which increase the rigidity of the middle lamella and cell wall, as well as the cell cohesion (**White and Broadley, 2003**). In this regard, calcium also delays membrane lipid catabolism and reduced physiological disorder (**Picchioni *et al*., 1998**). Similar results were obtained by **Atress & Rashid (2011) and Abdullah & Ibrahim (2018**) on cherry tomato.

Total soluble solids (Brix)

Total soluble solids content in cherry fruits increased with prolonging cold storage period up to 30 days compared to zero time for all treatments (Table 16). Pre-harvest foliar spraying with $CaCl_2$ at 2 % and B at 25 ppm or Mo at 5 ppm gave the highest values of TSS during cold storage periods in both seasons. $CaCl_2$ at 2 % and B at 25 ppm recorded 10.05 and 10.00 Brix^o at 30 days of cold storage in the 1st and 2nd seasons, respectively. The end of cold storage period, TSS for all treatments ranged from 8.35 to 10.05 Brix^o and from 8.29 to 10.0 Brix^o in the 1st and 2nd seasons, respectively (9.14 Brix^o as average two seasons). During cold storage period, there was positive correlation between fruit weight loss and TSS. Similarly, to the results were obtained by **Atress and Rashid (2011**) on cherry tomatoes.

Titratable acidity as citric acid

Titratable acidity in fruits decreased with the prolonging cold storage periods compared to zero time in both seasons for all treatments (Table 17). Pre-harvest foliar application with Ca citrate at 2 % and Mo at 5 ppm recorded maximum titratable acidity during cold storage periods in both seasons. The end of cold storage period, titratable acidity for all treatments ranged from 0.60 to 0.94 % in the 1st season and ranged from 0.61 to 0.98 % in the 2nd season, (0.78 % as average two seasons. The reduction of titratatble acidity as fruit ripens may be due to further oxidation of organic acids to sugar. The decrease in the content of acidity reduces the desire quality of fruits. Similar results were obtained by **Abdullah and Ibrahim (2018)** on cherry tomatoes.

Ascorbic acid (vitamin C)

Ascorbic acid contents showed continuous and shop reduction with advance in cold storage periods and gave the lowest values at 30 days of cold storage for all treatments (Table 18). Pre- harvest foliar application Ca citrate at 2 % and B at 25 ppm recorded maximum values of vitamin C during cold storage periods. At 30 days of cold storage, spraying with Ca citrate at 2 % + B at 25 ppm recorded 15.96 and 16.11 mg /100 ml juice in the 1st and 2nd seasons, respectively. The end of clod storage period, vitamin C for all treatments ranged from 14.16 to 15.96 mg/100 ml juice in the 1st season and ranged from 14.43 to 16.11 mg/100 ml juice in the 2nd season (15.16 mg/100 ml juice as average two seasons). During cold storage period, there were positive correlation among firmness, titratable acidity and vitamin C in fruits and there was negative correlation between TSS and titratable acidity in fruits.

The reduction of vitamin C during storage may be attributed to great metabolic activity during storage as it is respired (**Wills *et al*., 1981**) and higher rate of sugar loss through respiration than water loss through transpiration (**Paradis *et al*., 1995**). The increasing in vitamin C as a result of using Ca-Cit may be due to that citric acid have beneficial effect on preventing degradation of ascorbic acid by chelating contaminated metal ions in the system. Consequently, catalytic action of metal ions on the oxidation of ascorbic acid in the tomato fruits was inhibited (**Manurakchinakorn and Thirawut, 2009**).

These results are in harmony with results obtained by **Gad El-Rab (2013**) on sweet pepper, **Raafat *et al.* (2016) and Abdullah and Ibrahim (2018**) on cherry tomatoes.

From the foregoing results, it could be concluded results, during cold storage period, fresh weight loss (%) and TSS in fruits increased, whereas fruit firmness, titratable acidity and vitamin C in fruits decreased with prolonging cold storage periods for all treatments. Pre-harvest foliar application with Ca Cl_2 at 2 % and B at 25 ppm increased TSS and fruit firmness, whereas decreased fresh weight loss (%) during cold storage periods. Foliar spray with Ca citrate at 2 % and B at 25 ppm increased titratable acidity and vitamin C in fruits during cold storage periods.

Table 15. Effect of foliar application with calcium sources, some microelements and their combination pre-harvest on fruit firmness of cherry tomato fruits during cold storage in 2018/2019 and 2019/2020 seasons

Treatments		Fruit firmness (g/cm^3)				
		2018/2019 season				
Ca sources	Microelements	Storage period in days (S)				
		0	10	20	30	Mean(S)
Without	Control (water)	447.7	433.1	347.2	251.1	369.7
	B at 25 ppm	465.2	440.0	388.4	291.8	396.3
	Mo at 5 ppm	458.7	434.0	348.0	264.2	376.2
	Mean	457.2	435.7	361.2	269.0	**380.7**
Ca citrate at 2%	Control (water)	483.5	456.9	416.6	335.8	423.2
	B at 25 ppm	502.2	465.0	420.2	344.1	432.8
	Mo at 5 ppm	490.0	457.6	417.6	336.4	425.4
	Mean	491.9	459.8	418.1	338.8	**427.1**
Ca chloride at 2%	Control (water)	498.5	470.8	422.6	350.0	435.4
	B at 25 ppm	515.8	477.6	426.8	371.8	448.0
	Mo at 5 ppm	508.8	471.1	423.1	356.2	439.8
	Mean	507.7	473.1	424.1	359.3	**441.0**
Ca tartrate at 2%	Control (water)	470.0	444.4	396.0	310.6	405.3
	B at 25 ppm	487.4	451.3	405.8	326.7	417.8
	Mo at 5 ppm	482.0	446.3	402.6	314.7	411.4
	Mean	479.8	447.3	401.5	317.3	**411.5**
Mean(T)		**484.2**	**454.0**	**401.2**	**321.1**	---
Control		474.9	451.3	395.6	311.8	**408.4**
B at 25 ppm		490.9	456.8	409.3	329.7	**421.7**
Mo at 5 ppm		486.6	453.8	398.7	321.7	**415.2**
		2019/2020 season				
Without	Control (water)	453.3	437.1	362.6	260.0	378.3
	B at 25 ppm	469.9	443.3	396.5	301.1	402.7
	Mo at 5 ppm	463.8	437.5	362.3	279.8	385.9
	Mean	462.3	439.3	373.8	280.3	**388.9**
Ca citrate at 2%	Control (water)	486.2	458.7	411.6	337.7	423.6
	B at 25 ppm	494.1	466.1	421	346.6	432.0
	Mo at 5 ppm	487.6	460.0	418.3	338.0	426.0
	Mean	489.3	461.6	417	340.8	**427.2**
Ca chloride at 2%	Control (water)	497.8	473.8	425.5	352.4	437.4
	B at 25 ppm	508.1	479.3	429.7	372.3	447.4
	Mo at 5 ppm	492.7	474.2	426.2	357.5	437.7
	Mean	499.5	475.8	427.1	360.7	**440.8**
Ca tartrate at 2%	Control (water)	471.9	445.2	400.7	313.7	407.9
	B at 25 ppm	482.8	455.5	410.0	330.0	419.6
	Mo at 5 ppm	475.0	448.1	405.1	318.5	411.7
	Mean	476.6	449.6	405.3	320.7	**413.0**
Mean(T)		481.9	456.5	405.7	325.6	
Control		477.3	453.7	400.1	315.9	**411.8**
B at 25 ppm		484.8	459.7	413.4	333.8	**422.9**
Mo at 5 ppm		483.6	456.2	403.8	327.1	**417.7**

LSD at 5% season1 **Calcium sources (CaS)= 8.07** **Microelement (Mic)= 6.05** **CaS x Mic= 12.11** **Storage period (Sp) =6.57**

CaS x Sp = 13.15 **Mic x Sp=11.38** **CaS x Mic x Sp=22.78**

LSD at 5% season2 **Calcium sources (CaS)= 8.57** **Microelement (Mic)= 6.43** **CaS x Mic= 12.86** **Storage period (Sp) =6.98**

CaS x Sp = 13.97 **Mic x Sp= 12.09** **CaS x Mic x Sp=24.19**

Table 16. Effect of foliar application with calcium sources, some microelements and their combination pre-harvest on TSS of cherry tomato fruits during cold storage in 2018/2019 and 2019/2020 seasons

Treatments		**TSS**				
		2018/2019 season				
Ca sources	**Microelements**	**Storage period in days (Sp)**				
		0	**10**	**20**	**30**	**Mean**
Without	**Control (water)**	7.11	7.75	7.91	8.35	7.78
	B at 25 ppm	8.34	9.05	9.40	9.96	9.19
	Mo at 5 ppm	7.38	7.82	8.03	8.40	7.91
	Mean	7.61	8.21	8.45	8.90	**8.29**
Ca citrate at 2%	**Control (water)**	7.28	7.93	8.10	8.49	7.95
	B at 25 ppm	7.68	8.14	8.24	8.61	8.17
	Mo at 5 ppm	8.33	8.83	9.31	9.72	9.05
	Mean	7.76	8.30	8.55	8.94	**8.39**
Ca chloride at 2%	**Control (water)**	8.08	8.56	8.69	8.79	8.53
	B at 25 ppm	8.59	9.11	9.43	10.05	9.30
	Mo at 5 ppm	8.15	8.74	9.11	9.34	8.84
	Mean	8.27	8.80	9.08	9.39	**8.89**
Ca tartrate at 2%	**Control (water)**	8.02	8.50	8.63	8.72	8.47
	B at 25 ppm	8.12	8.61	8.95	9.23	8.73
	Mo at 5 ppm	8.10	8.80	9.29	9.65	8.96
	Mean	8.08	8.64	8.96	9.20	**8.72**
Mean(T)		**7.93**	**8.49**	**8.76**	**9.11**	---
Control		7.62	8.18	8.33	8.58	**8.18**
B at 25 ppm		8.18	8.72	9.00	9.46	**8.84**
Mo at 5 ppm		7.99	8.54	8.93	9.27	**8.68**
		2019/2020 season				
Without	**Control (water)**	7.00	7.42	7.32	8.29	7.51
	B at 25 ppm	7.22	7.69	8.00	8.40	7.83
	Mo at 5 ppm	7.27	7.63	7.94	8.35	7.80
	Mean	7.16	7.58	7.75	8.35	**7.71**
Ca citrate at 2%	**Control (water)**	8.37	9.00	9.31	9.80	9.12
	B at 25 ppm	7.71	8.10	8.16	8.55	8.13
	Mo at 5 ppm	8.38	8.80	9.28	9.68	9.04
	Mean	8.15	8.63	8.92	9.34	**8.76**
Ca chloride at 2%	**Control (water)**	7.85	8.24	8.43	8.67	8.30
	B at 25 ppm	8.64	9.07	9.35	10.00	9.27
	Mo at 5 ppm	8.33	8.75	9.16	9.55	8.95
	Mean	8.27	8.69	8.98	9.41	**8.83**
Ca tartrate at 2%	**Control (water)**	7.69	8.28	8.41	8.73	8.28
	B at 25 ppm	8.11	8.62	8.86	9.25	8.71
	Mo at 5 ppm	8.12	8.53	8.72	8.97	8.59
	Mean	7.97	8.48	8.66	8.98	**8.52**
Mean(Sp)		**7.89**	**8.34**	**8.57**	**9.02**	---
Control		7.72	8.23	8.36	8.87	**8.30**
B at 25 ppm		7.92	8.37	8.59	9.05	**8.48**
Mo at 5 ppm		8.02	8.42	8.77	9.13	**8.59**
LSD at 5% season1	**Calcium sources (CaS)= 0.09**	**Microelement (Mic)= 0.06**	**CaS x Mic= 0.13**	**Storage period (Sp) =0.07**		
	CaS x Sp = 0.15	**Mic x Sp=0.13**	**CaS x Mic x Sp=0.26**			
LSD at 5% season2	**Calcium sources (CaS)= 0.10**	**Microelement (Mic)= 0.07**	**CaS x Mic= 0.15**	**Storage period (Sp) =0.08**		
	CaS x Sp = 0.16	**Mic x Sp= 0.14**	**CaS x Mic x Sp=0.28**			

Table 17. Effect of foliar application with calcium sources, some microelements and their combination pre-harvest on acidity of cherry tomato fruits during cold storage in 2018/2019 and 2019/2020 seasons

Treatments		**Acidity (%)**				
		2018/2019 season				
Ca sources	**Microelements**	**Storage period in days (Sp)**				
		0	**10**	**20**	**30**	**Mean**
Without	**Control (water)**	0.90	0.86	0.70	0.60	0.76
	B at 25 ppm	0.97	0.92	0.80	0.66	0.83
	Mo at 5 ppm	1.16	1.10	1.02	0.86	1.04
	Mean	1.01	0.96	0.84	0.71	**0.87**
Ca citrate at 2%	**Control (water)**	1.23	1.13	1.07	0.94	1.09
	B at 25 ppm	1.05	1.00	0.86	0.70	0.90
	Mo at 5 ppm	1.19	1.11	1.04	0.86	1.05
	Mean	1.16	1.08	0.99	0.83	**1.02**
Ca chloride at 2%	**Control (water)**	1.09	1.04	0.94	0.74	0.95
	B at 25 ppm	0.92	0.88	0.71	0.63	0.79
	Mo at 5 ppm	0.99	0.91	0.76	0.64	0.83
	Mean	1.00	0.94	0.80	0.67	**0.85**
Ca tartrate at 2%	**Control (water)**	1.17	1.07	1.00	0.81	1.01
	B at 25 ppm	1.03	0.94	0.83	0.69	0.87
	Mo at 5 ppm	1.10	1.05	0.94	0.76	0.96
	Mean	1.10	1.02	0.92	0.75	**0.95**
Mean(Sp)		**1.06**	**1.00**	**0.88**	**0.74**	
Control		1.09	1.02	0.92	0.77	**0.95**
B at 25 ppm		0.99	0.93	0.80	0.67	**0.84**
Mo at 5 ppm		1.11	1.04	0.94	0.78	**0.96**
		2019/2020 season				
Without	**Control (water)**	0.93	0.89	0.70	0.61	0.78
	B at 25 ppm	1.01	0.96	0.83	0.70	0.88
	Mo at 5 ppm	1.20	1.14	1.07	0.90	1.08
	Mean	1.05	1.00	0.87	0.74	**0.91**
Ca citrate at 2%	**Control (water)**	1.20	1.18	1.12	0.98	1.12
	B at 25 ppm	1.08	1.03	0.93	0.76	0.95
	Mo at 5 ppm	1.16	1.15	1.08	0.92	1.08
	Mean	1.15	1.12	1.04	0.88	**1.05**
Ca chloride at 2%	**Control (water)**	1.08	1.08	0.98	0.76	0.99
	B at 25 ppm	0.99	0.93	0.78	0.68	0.85
	Mo at 5 ppm	0.95	0.90	0.72	0.62	0.80
	Mean	1.02	0.97	0.83	0.69	0.88
Ca tartrate at 2%	**Control (water)**	1.16	1.10	1.02	0.86	**1.04**
	B at 25 ppm	1.05	1.00	0.89	0.72	0.92
	Mo at 5 ppm	1.17	1.08	1.00	0.80	1.00
	Mean	1.11	1.06	0.97	0.79	0.98
Mean(Sp)		**1.08**	**1.06**	**0.95**	**0.80**	
Control		1.09	1.06	0.95	0.80	**0.97**
B at 25 ppm		1.03	0.98	0.85	0.71	**0.89**
Mo at 5 ppm		1.12	1.06	0.96	0.81	**0.99**

LSD at 5% season1	**Calcium sources (CaS)= 0.01**	**Microelement (Mic)= 0.01**	**CaS x Mic= 0.03**	**Storage period (Sp) =0.02**
	CaS x Sp = 0.03	**Mic x Sp=0.03**	**CaS x Mic x Sp=0.06**	
LSD at 5% season2	**Calcium sources (CaS)= 0.01**	**Microelement (Mic)= 0.01**	**CaS x Mic= 0.02**	**Storage period (Sp) =0.01**
	CaS x Sp = 0.03	**Mic x Sp= 0.02**	**CaS x Mic x Sp=0.05**	

Table 18. Effect of foliar application with calcium sources, some microelements and their combination pre-harvest on vitamin C of cherry tomato fruits during cold storage in 2018/2019 and 2019/2020 seasons

Treatments		Vitamin C mg/100ml juice				
		2018/2019 season				
Ca sources	Microelements	Storage period in days (Sp)				
		0	10	20	30	Mean
Without	Control (water)	16.44	15.70	15.40	14.16	15.43
	B at 25 ppm	16.80	16.00	15.70	14.53	15.76
	Mo at 5 ppm	16.52	15.73	15.41	14.21	15.47
	Mean	16.59	15.81	15.50	14.30	**15.55**
Ca citrate at 2%	Control (water)	17.88	16.65	16.45	15.80	16.70
	B at 25 ppm	18.90	17.33	17.21	15.96	17.35
	Mo at 5 ppm	17.51	16.68	16.47	15.81	16.62
	Mean	18.10	16.89	16.71	15.86	**16.89**
Ca chloride at 2%	Control (water)	17.14	16.32	16.18	15.28	16.23
	B at 25 ppm	17.26	16.53	16.33	15.63	16.44
	Mo at 5 ppm	17.16	16.34	16.18	15.47	16.29
	Mean	17.19	16.40	16.23	15.46	**16.32**
Ca tartrate at 2%	Control (water)	16.89	16.09	15.79	14.77	15.89
	B at 25 ppm	17.06	16.19	16.05	15.19	16.12
	Mo at 5 ppm	16.95	16.14	16.00	15.03	16.03
	Mean	16.97	16.14	15.95	15.00	**16.01**
Mean(T)		**17.20**	**16.30**	**16.09**	**15.15**	
Control		17.08	16.19	15.95	15.00	**16.05**
B at 25 ppm		17.50	16.51	16.32	15.32	**16.41**
Mo at 5 ppm		17.03	16.22	16.01	15.13	**16.10**
		2019/2020 season				
Without	Control (water)	16.85	15.90	15.53	14.43	15.68
	B at 25 ppm	17.29	16.12	15.86	14.60	15.97
	Mo at 5 ppm	16.91	15.95	15.56	14.43	15.71
	Mean	17.02	15.99	15.65	14.49	**15.79**
Ca citrate at 2%	Control (water)	19.51	18.31	17.67	15.90	17.85
	B at 25 ppm	19.99	18.67	17.45	16.11	18.06
	Mo at 5 ppm	19.83	18.33	17.67	15.93	17.94
	Mean	19.78	18.44	17.60	15.98	**17.95**
Ca chloride at 2%	Control (water)	18.22	17.19	16.56	15.33	16.83
	B at 25 ppm	18.56	17.70	17.00	15.94	17.30
	Mo at 5 ppm	18.65	17.22	16.72	15.55	17.04
	Mean	18.48	17.37	16.76	15.61	**17.05**
Ca tartrate at 2%	Control (water)	17.18	16.21	15.94	14.81	16.04
	B at 25 ppm	17.56	16.57	16.22	15.25	16.40
	Mo at 5 ppm	17.24	16.36	16.10	15.10	16.20
	Mean	17.33	16.38	16.09	15.05	**16.21**
Mean(Sp)		**18.14**	**17.04**	**16.52**	**15.28**	**--**
Control		17.94	16.90	16.42	15.11	**16.56**
B at 25 ppm		18.35	17.26	16.63	15.47	**16.93**
Mo at 5 ppm		18.15	16.96	16.51	15.25	**16.72**

LSD at 5% season1 **Calcium sources (CaS)= 0.11** **Microelement (Mic)= 0.08** **CaS x Mic= 0.17** **Storage period (Sp) =0.09**

CaS x Sp = 0.19 **Mic x Sp=0.16** **CaS x Mic x Sp=0.33**

LSD at 5% season2 **Calcium sources (CaS)= 0.19** **Microelement (Mic)= 0.14** **CaS x Mic= 0.28** **Storage period (Sp) =0.15**

CaS x Sp = 0.31 **Mic x Sp= 0.26** **CaS x Mic x Sp=0.53**

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RESEARCH ARTICLE

Improvement, Productivity, Fruit Quality and Storability of Cherry Tomato Via Foliar Application with Different Calcium Sources and Some Micronutrients

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