The role of calcium and silicon in treating some physiological disorder and improving fruits quality characteristics of two tomato cultivars

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ABSTRACT

The experiment was carried out in the vegetable field of the Department of Horticulture and Landscape Engineering / College of Agriculture and Forestry / University of Mosul, in the agricultural season of 2020 and 2021, to treat some fruits physiological disorder of two varieties of tomato cultivars (*Lycopersicon esculentum* Mill). The soil was well and homogeneous and divided into parts, the study included two different factors, two varieties of tomato (Super Queen and Persin) as the first factor and spraying with different concentrations of calcium chloride (0.0, 0.5 and 1%) and Sodium silicate (0.0, 0.25 and 0.50%) as the second factor in addition to control treatment The spraying process was carried out with calcium chloride $CaCl_2$ and sodium silicate after forming 7-8 real leaves on 5/9/2020. The spraying was repeated three times, two-week interval. The experiment was carried out using the split-plot system, with in randomized block design (R.C.B.D) where the cultivars placed in the main plot and the reast treatments were distilbuted randomly in the second plot Three replications for treatment, each experimental unit included (7) plants, so the total number of treatments reached to ten. The qualitative characteristics of fruits: No significant differences were found between the two cultivars Super Queen and Persin in the qualitative fruits characteristics. Spraying with calcium chloride at a concentration of 1% led to a significant increase in the percentage of total soluble solids (TSS) and the percentage of total terrible acidity (TTA), while all treatments of calcium chloride and sodium silicate at both concentrations caused a significant reduction in physiological disorder (the Blossom end rot, cracking of fruits and sun blight) and events significant increase in the percentage of healthy fruits as compared with the control treatment. The results showed the interaction of both cultivars and the spraying treatment with calcium chloride at a concentration of 1%, cawied a significant increase in the percentage of (TSS) , (TTA) and a significant reduction in physiological fruit disorder (Blossom end rot and sun blight), while spraying plants of Super Queen cultivar with calcium chloride at a concentration of 1% calcium and sodium silicate at a concentration of 0.50% led to a significant increase in the percentage of healthy fruits, and the interaction between both cultivars and spraying with sodium silicate at a concentration of 0.50% caused a significant reduction in physiological fruit disorder (the Blossom end rot, fruit cracking and sun blight), as compared to the control treatment.

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Introduction

Tomato (*Lycopersicon esculentum* Mill) is one of the most important vegetable crops belonging to the Solanaceae family. This family includes about 90 genera, and about 2000 species. It is the most common in most parts of the world and is widely cultivated in many countries of the world. It is considered one of the basic vegetable crops in nutrition for most peoples, discovered in Europe in the sixteenth century, where it was mentioned for the first time, and the demand for cultivation and consumption of tomatoes remained limited; Because of the widespread misconception that its fruits are poisonous to humans. Perhaps the reason for this is that its fruits are similar to other types of nightshade with poisonous fruits. In the middle of the nineteenth century, the expansion of tomato cultivation began in the United States, and then in the rest of the world (Esquinas-Alcazar, 1981; Tigchelaar, 1986; Tigchelaar and Foley, 1991). Tomato is used fresh with food, in salads, or in cooking. It is also considered one of the main manufacturing vegetables, where the fruits are canned whole after removing the skin of the fruit, or used in the manufacture of sauce (paste), ketchup, soup, and many other products. It is considered of high nutritional value, as each 100 grams of fresh tomato contains 93.5 grams of water, 22 calories, 1.1 grams of protein, 4.7 grams of total carbohydrates, 13 milligrams of calcium, 27 milligrams of phosphorous, 0.5 milligrams of iron, and 244 milligrams Potassium (Watt & Merrill, 1963). Tomatoes are a good source of many vitamins A, C, Ca, Fe, protein, Na, K, and Mg (USDA, 2016).

The productivity of annual tomatoes fluctuates as a result of being infected with some physiological disorders, which do not arise from pathogens or insect pests. Deviation of one or more environmental factors affecting it during the stages of plant growth and maturity. They are also called non-communicable diseases because they are not transmitted from an infected plant to a healthy one, so we do not use chemical pesticides to control them, but we need to apply agricultural methods and precautionary measures to reduce them.(Hassan, 1989).

Fertilization is one of the important agricultural operations that have a role in the nature of growth, flowering and fruiting, both quantitatively and qualitatively, and the method of adding fertilizers through leaves by spraying (foliar feeding) is one of the efficient and important and successful methods for treating nutrient deficiencies, especially the smaller ones (Abu Dahi, 1989).

Silicon fertilization has an effect on the plant as it stimulates the plant to develop some of the mechanisms that enable it to resist or withstand various stress conditions, whether biological or abiotic stress (Matichenkov et al., 2000). As it is absorbed by plants in the form of H_4SiO_4 at rates ranging about (50-150) kg.ha-1 (Matichenkov et al., 2000). Silicon (Si) is one of the useful elements, although it is not present in the list of elements necessary for plant growth, and it has important roles in many physiological processes, the most important of which are improving the efficiency of photosynthesis, increasing the effectiveness of roots to absorb nutrients necessary for plant growth and development, reducing the toxicity of the Na^+ ion. Increasing the ratio of Na^+ to K^+, increasing the activity of antioxidant enzymes, and decreasing the toxicity of heavy metals. (Liang et al., 2006 and Adrees et al., 2015).

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Vinh et al. (2018) found that the addition of calcium to the nutrient solution at a concentration of 0.05 mg.g-1 for the tomato cultivars Momotaro Fight and Cindy Sweet and the relationship between the blossom end rot and the size of the fruit, the cultivar Momotaro Fight with large fruits is more sensitive to with blossom end rot. Of the fruits of Cindy Sweet cultivar with medium-sized fruits, calcium treatment caused a significant reduction in the incidence of this disease in both cultivars.

Zamban et al. (2018) observed in a study on two hybrids of Italian tomatoes (San Vito and Neptuno) that spraying with calcium chloride at a concentration of 0.6% every two weeks led to a significant reduction in the incidence of blossom end rot compared to the control treatment.

Between Riboldi et al. (2019) Calcium deficiency in tomato fruits blossom end rot (BER), where the infection begins with the appearance of small spots of light brown color and stops the growth of the affected tissue and then gradually turns black or brown in the distant tissues of the fruit.

Cruz Araújo et al. (2020) indicated that calcium is important in the growth and development of tomato plants, and its deficiency causes many problems, blossom end rot (BER) for fruits.

Reitz and Mitcham (2021) indicated the blossom end mold (BER) disease in tomato causes a significant losses in production in general, BER consists of small spots and cell death in, especially in the half of the fruit far from the neck. This is followed by blackening and sometimes drying of the affected tissues. BER occurs during fruit development before physiological ripening, while calcium deficiency increases the rate of hystrophy.

Materials and methods

This experiment was carried out in the vegetable field of the Department of Horticulture and Landscape Engineering / College of Agriculture and Forestry / University of Mosul, in the agricultural season of 2020-2021, the land designated for cultivation was prepared and plowed with a flip-up plow in an orthogonal manner and smoothed, then the soil was leveled well and homogeneously and divided into two parts, the experiment included three Replicators, ten treatments, and each experimental unit contained seven plants. The area of the experimental unit was 2.8 m2 (2.8 m length x 1 m width) and a distance of 50 cm was left between one bench and another and 50 cm between one replicate and another to prevent mixing fertilizers. The seeds were sown in the plastic house in the Al-Ahly flower nursery in Nineveh Governorate on February 29, 2020 in small anvils with a diameter of 5 cm. A mixture of sand and peat moss was prepared at a ratio of 3:1 as a medium for planting. The fungicide Peltanol was used at a concentration of 0.75 cm3.l- 1 after planting the seeds. Before transferring the seedlings to the permanent field and when it reached the stage of forming the third true leaf, it was hardened for 7 days on 5/4/2020 by taking the seedlings out of the plastic house daily in the morning and exposing them to sunlight and returning them in the evening and reducing the number of irrigations by drying the plants and increasing the period between watering and others (matlob and others 1989). Agricultural service operations were carried out identically for all experimental units of fertilization, weeding, export, preventive and curative control operations for diseases, insects and bushes. Urea 46% N fertilizer was added before planting seedlings at a rate of (25 g / experimental unit) and two weeks after seedling, NPK 15:15 fertilizer was added: 15 from the German Neufarm company in the amount of 168 g/experimental unit and in three batches, where the first batch was added on 4/28/2020 and 15 days between batches by digging a groove on the side of the terrace and at a distance of 15 cm from the plants, and the export process was carried out three weeks after The seedling was also conducted by hand weeding on a continuous basis whenever needed, and the drip irrigation system was followed according to the weather conditions of the governorate.

The study included two cultivars of tomato (Super Queen and Persin) as the first factor and spraying with different concentrations of calcium chloride and sodium silicate factor spraying calcium chloride at a three concentrations of 0.0, 0.5% and 1%, spraying with sodium silicate at a three concentrations (0.0, 0.25% and 0.50%) as a second factor. The spraying process was carried out with calcium chloride CaCl2 and sodium silicate after the formation of 7-8 real leaves on 9/5/2020. The spraying process was repeated three times, two weeks interval. The experiment was carried out using the split-plots system, whit in randomized complet block design where the cultivars were placed in the main plots and the rest of the treatments were randomly distributed sub-plots using the R.C.B.D design (Al-Rawi and Khalaf Allah, 2000). The objective of this study: To reduce the incidence of physiological disorders to tomato fruits, especially the blossom end rot , cracking of the fruits and sun blight and increasing the percent loge of marketable marketing yield of tomatoes.

Studied traits:

1- Percentage of total soluble solids in fruit juice:

The percentage of dissolved solids was estimated by taking several drops of tomato juice using a spectral refractor device (Handrefractometer) and ten readings were taken and the average was extracted.

2- Total titratableacidity in fruit juice:

The percentage of acidity in tomato juice was estimated according to (Ranganna, 1977) method, by sweeping 10 ml of filtered (full-ripe) tomato juice with sodium hydroxide (0.1 N) and in the presence of phenonnaphthylene evidence on the basis that the predominant acid was citric acid.

3- Percentage of infection with Blossom end rot:

The percentage of Blossom end rot:

$$\text{Percentage of fruits infected with Blossom end rot} = \frac{\text{The number of fruits Blossom end rot}}{\text{The sum of the total number of fruits}} \times 100$$

4- Percentage of fruit cracking:

The percentage of fruit cracking was measured as follows:

$$\text{Percentage of cracked fruits} = \frac{\text{The number of cracked fruits}}{\text{The sum of the total number of fruits}} \times 100$$

5-Percentage of sun blight:

The percentage of sun blight infection was measured as follows:

$$\text{Percentage of fruits affected by sun blight} = \frac{\text{The number of fruits affected by sun blight}}{\text{The sum of the total number of fruits}} \times 100$$

6-Percentage of healthy fruits:

The percentage of healthy fruits that are free from all physiological disorder was measured as follows:

$$\text{Percentage of healthy fruits} = \frac{\text{The number of healthy fruits}}{\text{The sum of the total number of fruits}} \times 100$$

Results and discussion

Effect of spraying with calcium and silicon in treating some physiological disorder and improving the qualitative characteristics of the fruits of two cultivars of tomato.

1- cultivars effect:

Tables (1, 2, 3, 4, 5 and 6) show that there are no significant differences between the two cultivars Super Queen and Persin in the characteristics of (TSS, T.T.A., percentage of fruits affected by Blossom end rot, cracks,. sun blight and healthy fruits) respectively.

2- Effect of spray treatments:

Tables (1, 2 and 3) show that the spraying treatment with calcium chloride at a concentration of 1% was significantly superior to the increase in the percentage of total dissolved solids (TSS) and the percentage of acidity in the fruit juice and a significant reduction in the percentage of fruits affected by Blossom end rot which resulted from the treatment of spraying with sodium silicate. With a concentration of 0.50%, a significant reduction in the percentage of fruits infected with cracks and fruits infected with sun blight as compared to the control treatment (Tables 4 and 5) respectively, while all spraying treatments with calcium chloride and sodium silicate with both concentrations caused a significant increase in the percentage of healthy fruits compared to the control treatment (Table 6).

As for the effect of the interaction treatments between the cultivar and the spraying treatments, the highest percentage of TSS was recorded as a result of spraying Persin plants with calcium chloride at a concentration of 1%, and thus it outperformed all the interaction treatments except the treatment spraying Super Queen plants with the same concentration (Table 1), while the treatment of spraying plants of two cultivars Super Queen and Persin with calcium chloride at a concentration of 1% significantly increased the acidity percentage in the fruit juice, which amounted to 1.101 and 1.117. and the lowest percentage of fruits Blossom end rot was 3.35 and 1.20, respectively (Tables 2 and 3). while the lowest percentage of fruits infected with cracks that amounted to 3.43 recorded in plants of super Queen treated with 0.50% sodium silicate (Table 4), thus it

Table (1) Effect of calcium chloride $CaCl_2$ and sodium silicate Na_2SiO_3 spraying on the percentage of TSS in the juice of two cultivars of tomato Super Queen and Persin.

treatments	The effect of spraying with calcium chloride and sodium silicate					effect cultivar
cultivars	0	Calcium Chloride 0.5%	Calcium Chloride 1%	Sodium Silicate 0.25%	Sodium Silicate 0.50%	
Super Queen	4.55 c	5.10 bc	5.62 ab	4.77 c	5.05 bc	5.02 a
Persin	4.66 c	5.16 bc	5.86 a	4.89 c	5.13 bc	5.14 a
spray	4.60 c	5.13 b	5.74 a	4.83 bc	5.09 b	

* The averages with the same letter or letters within the single coefficients or the overlap, there is no significant difference between them according to Duncan's test and under the 0.05% probability level.

The treatment of spraying Persin plants with sodium silicate at a concentration of 0.50% was significantly superior by giving the lowest percentage of the fruits infected with blight. as compared to the control treatment for both cultivars While the two treatments of spraying plants of the cultivar Super Queen with calcium chloride at a concentration of 1% and spraying with sodium silicate in at 0.50% give to a significant increase in the percentage of healthy fruits amounted to 78.42 and 78.45, respectively (Table 6). Spraying plants with calcium and at both concentrations led to a significant increase in the percentage of dissolved solids (Table 1) and the percentage of total acidity in the fruits (Table 2). Reducing the physiological disorders represented by reducing percentage the Blossom end rot (Table 3), cracking the fruit (Table 4) and sun blight (Table 5) white cede to significant increasing the percentage of healthy fruits(Table 6) as compared to control treatment, this is due to the fact that the lack of calcium in the fruits is a local deficiency as a result of a slow and poor distribution of the calcium element between the vegetative total and the fruits. The local deficiency in the element of calcium may occur as a result of the transfer of calcium from the root system to the vegetative system in the main with the moving water towards the sites of the transpiration process, and this means that the leaves contain a group of mineral elements in addition to calcium.

Table (2) Effect of calcium chloride CaCl2 and sodium silicate Na2Sio3 spraying on the percentage of total acidity (T.T.A) in the juice of two cultivars of tomato Super Queen and Persin.

treatments						**effect cultivar**
cultivars	**The effect of spraying with calcium chloride and sodium silicate**					
	0	**Calcium Chloride 0.5%**	**Calcium Chloride 1%**	**Sodium Silicate 0.25%**	**Sodium Silicate 0.50%**	
Super Queen	**0.921 bc**	**0.998 b**	**1.101 a**	**0.877 cd**	**0.998 b**	**0.979 a**
Persin	**0.750 e**	**0.998 b**	**1.117 a**	**0.827 de**	**0.947 bc**	**0.928 a**
effect of spray treatments	**0.836 c**	**0.998 b**	**1.109 aأ**	**0.852 c**	**0.972 b**	

* The averages with the same letter or letters within the single coefficients or the overlap, there is no significant difference between them according to Duncan's test and under the 0.05% probability level.

Table (3) Effect of calcium chloride CaCl2 and sodium silicate Na2Sio3 spraying on the percentage of fruits Blossom end rot of two cultivars of tomato Super Queen and Persin.

treatments						**effect cultivar**
cultivars	**The effect of spraying with calcium chloride and sodium silicate**					
	0	**Calcium Chloride 0.5%**	**Calcium Chloride 1%**	**Sodium Silicate 0.25%**	**Sodium Silicate 0.50%**	

Super Queen	**45.01 a**	**14.73 cd**	**3.35 f**	**14.03 c-e**	**6.95 ef**	**16.81 a**
Persin	**33.86 b**	**12.22 c-e**	**1.20 f**	**19.34 c**	**10.56 de**	**15.43 a**
effect of spray treatments	**39.43 a**	**13.47 bc**	**2.28 d**	**16.68 b**	**8.75 c**	

* The averages with the same letter or letters within the single coefficients or the overlap, there is no significant difference between them according to Duncan's test and under the 0.05% probability level. The rate of transpiration by fruits is low compared to the leaves, and thus the water transferred to it from the roots is less, and accordingly the amount of Calcium accumulated in it because calcium follows the direction of the movement of transpiration water in its transfer (Wiersum, 1966).

Table (4) Effect of calcium chloride CaCl2 and sodium silicate Na2Sio3 spraying on the percentage of cracked fruits of two cultivars of tomato Super Queen and Persin.

treatments						
cultivars	**The effect of spraying with calcium chloride and sodium silicate**					**effect cultivar**
	0	**Calcium Chloride 0.5%**	**Calcium Chloride 1%**	**Sodium Silicate 0.25%**	**Sodium Silicate 0.50%**	
Super Queen	**12.29 ab**	**6.35 cd**	**5.80 cd**	**7.70 b-d**	**3.43 d**	**7.11 a**
Persin	**13.76 a**	**8.93 bc**	**8.44 b-d**	**6.45 cd**	**4.32 cd**	**8.38 a**
effect of spray treatments	**13.02 a**	**7.64 b**	**7.12 bc**	**7.07 bc**	**3.87 c**	

* The averages with the same letter or letters within the single coefficients or the overlap, there is no significant difference between them according to Duncan's test and under the 0.05% probability level.

Table (5) Effect of calcium chloride CaCl2 and sodium silicate Na2Sio3 spraying on the percentage of fruits affected by sun blight of two cultivars of tomato Super Queen and Persin.

treatments						
cultivars	**The effect of spraying with calcium chloride and sodium silicate**					**effect cultivar**
	0	**Calcium Chloride 0.5%**	**Calcium Chloride 1%**	**Sodium Silicate 0.25%**	**Sodium Silicate 0.50%**	
Super Queen	**22.77 a**	**12.64 bc**	**12.42 bc**	**12.23 bc**	**10.27 bc**	**14.06 a**
Persin	**20.42 a**	**12.87 b**	**11.32 bc**	**12.54 bc**	**8.76 c**	**13.18 a**
effect of spray treatments	**21.60 a**	**12.75 b**	**11.87 bc**	**12.38 b**	**9.51 c**	

* The averages with the same letter or letters within the single coefficients or the overlap, there is no significant difference between them according to Duncan's test and under the 0.05% probability level.

It is the transfer of calcium in fruits to leaves under conditions of moisture stress that occurs when temperature rises and hot winds blow at the end of spring, these conditions will cause the leaves to draw water from the fruits to achieve the moisture balance between the fruits and leaves. The transfer of water from the fruits to the leaves will take with it the calcium dissolved in the juice of the fruit or in the water to the leaves, which leads to a local deficiency of this element in the fruit (Al-Ani, 1978). Another evidence of the localized deficiency of calcium at the tip of the fruit far from its stem (the flower tip), which occurs as a result of the withdrawal of calcium from the flowery tip towards the stem during the transfer of water from the fruit to the vegetative system, is that the fruit takes most of its needs of water and food through the bark, and from Calcium is known to be slow moving in the bark, and that the transfer of calcium is through the vessels of wood in the first place, and that the arrival of calcium to the bark leads to the fixation and transformation of most of it into an unready form because it unites, interacts or binds with many compounds found in the bark (Epstein, 1972).

Table (6) Effect of calcium chloride CaCl2 and sodium silicate Na2Sio3 spraying on the percentage of healthy fruits of two cultivars of tomato Super Queen and Persin.

treatments						**effect cultivar**
cultivars	**The effect of spraying with calcium chloride and sodium silicate**					
	0	**Calcium Chloride 0.5%**	**Calcium Chloride 1%**	**Sodium Silicate 0.25%**	**Sodium Silicate 0.50%**	
Super Queen	**19.93 c**	**63.02 ab**	**78.42 a**	**66.03 ab**	**78.45 a**	**61.17 a**
Persin	**31.95 bc**	**65.97 ab**	**54.81 a-c**	**62.27 ab**	**55.35 a-c**	**54.06 a**
effect of spray treatments	**25.94 b**	**64.50 a**	**66.61 a**	**64.15 a**	**66.90 a**	

* The averages with the same letter or letters within the single coefficients or the overlap, there is no significant difference between them according to Duncan's test and under the 0.05% probability level.

Calcium deficiency leads to physiological disorder to fruits, which is one of the most important causes of fruit damage and low quality in the field and during storage, this is due to may the bivalent nature of calcium, which increases the strength of cell walls inside the fruits through the formation of pectins that bind with calcium and increase the resistance of fruits to internal pressure, (Siddiqui and Bangerth, 2004). This positive effect of calcium in improving the quality characteristics of tomato fruits (Abd al-Rahman, 2011) may be explained by the increase in the thickness of the fruit rind, perhaps due to its role in strengthening and durability of cell walls through its participation in the formation of the middle plate of cell walls and the difference in thickness of cell layers and walls as a result of the formation of pectates Calcium (Abu Dahi and youssef, 1988) As for the significant effect of calcium in reducing the percentage of physiological disorders (Blossom end rot, cracking, and sun blight) it may be due to its role in increasing the thickness of the epidermal layer and cell walls and strengthening and durability of cell walls through its entry into the formation of the middle plate of cell walls As a result of the formation of calcium pectate, which makes it more capable of resisting pectin-degrading enzymes secreted by microorganisms when they cause injury (Abu Dahi and Youssef, 1988). Calcium also contributes to the binding of pectin with protein in the cell membranes of cell walls and binds adjacent cells (Nakata, 2003). This makes the cell walls and membranes more solid and cohesive, and calcium also plays a role in improving the quality characteristics of the fruits, because it is found in the cell walls in the form of a compound Calcium pectate within the formation of the middle lamella between the cell walls, which works to hold the primary walls of adjacent cells together. Calcium deficiency weakens the permeability of cell membranes and becomes more exuded, and this leads to the breakdown of the membrane structure and the diffusion of inorganic and organic compounds to the outside of the cell. Therefore, calcium deficiency encourages an increase in the infection of the blossom end rot in fruits Tomato (Hecht-Buchholzch ,1979). This is in line with Dawood (1986), who showed that there is a direct relationship between the thickness of the fruit wall and the resistance to cracking and fissuring and the Blossom end rot and that the addition of calcium by spraying is more effective in reducing the infection of fruits as a result of the increase and hardness of the thickness of the cell walls that comes from increased swelling of cells and thus stimulating tension In cell membranes and reduce permeability, and in line with Dris (1998) mentioned that element calcium works to hold adjacent cells in the cell wall and maintains the integrity of cell membranes and delays their aging by reducing the respiration process and the rate of ethylene production, and calcium contributes with some other elements (B, Mn, Cl ,Na,K) in regulating the osmotic potential of plant cells. Calcium has an important role as it reduces the occurrence of fruit cracking. The nature of the divalent calcium that increases the strength of the cell walls inside the fruits by forming pectates that bind with calcium and increase the resistance of the fruits to internal stress (Siddiqui and Bangerth, 2004). This is consistent with what Wei et al. (2008) mentioned that calcium has an active and positive role in regulating the osmotic effort of cells and keeping cells in a state of fullness under water stress conditions, in addition to regulating the process of osmosis and maintaining the hormonal balance inside the plant and maintaining the stability and composition of cell membranes, as well as inhibiting the effectiveness of many of oxidation enzymes under aqueous stress conditions. Saure (2009) indicated that the occurrence of Blossom end rot to a lack of calcium, or the cause may be a kind of tension as a result of a lack of soil water, high salinity, or high activity of ammonium or potassium, causing the destruction of the fruit walls and the leakage of cell fluids, and this occurs in Young fruits when the cell expands, as calcium at this stage is the least that causes BER. Djangsou et al. (2019) also indicated that the Blossom end rot of the tomato plant is based on two theories, the first is a low absorption of nutrients by the roots, especially calcium, while the second assumes a key role for environmental factors, which leads to the disintegration of membranes and the loss of turgor cells. Genetic, physiological, and environmental factors include a of interactions that Blossom end rot BER. Kemble and Sikora (2020) confirmed that hysteria syphilis is a physiological disorder caused by stress factors (dehydration) and that it is not a disease caused by fungi, bacteria or other pathogens, and BER occurs due to calcium deficiency, which usually occurs due to fluctuations In the water supply of the plant. Because calcium is slow moving in plants, dry soil or root damage from improper planting (extreme root pruning) can restrict water intake, thus preventing plants from getting the calcium they need. The Blossom end rot of calcium the qualitative yield of the tomato cultivars Super Queen and Persin under this study is similar consistent with what was found by Vinh et al. (2018), Zamban et al. (2018), Riboldi et al. (2019), Cruz Araujo et al. (2020), Reitz and Mitcham (2021) when treating other varieties of tomato plants with calcium.

As for the silicon element in improving the characteristics of the qualitative yield of the two types of tomato Super Queen and Persin approved in the study, it is noted from tables (1, 2, 3, 4, 5 and 6) that the spray treatment with a concentration of 0.25 and 0.50% was superior to the control treatment in increasing the percentage of dissolved solids The percentage of acidity in the fruits and a reduction in the incidence of Blossom end rot of the syphilis and cracking of fruits and sun blight and a significant increase in the percentage of healthy fruits compared to the comparison treatment where spraying with a concentration of 0.50% of silicon was the most effective treatment in all the above-mentioned traits, and these results are similar with what was found by Guerriero et al. (2016) Silicon works to increase the strength of cell walls, which leads to mechanical support of the aerial parts of the plant. And the protection of crops by deposition in the cell walls such as silica, which forms a mechanical barrier to the entry of pathogens, which enhances the production of fruits and their preservation after harvest (Hoffmann et al., 2020), and the addition of nano-silicon to the nutrient solution of strawberry plants before and after flowering led to an improvement in the thickness of the cell wall And providing a higher content of water, which leads to an increase in the content of chlorophyll (Avestan et al., 2021). The increase in the percentage of dissolved solids may be explained by the decrease in the water content in the fruit (Lu et al., 2003). The accumulation of sugars is a natural response to stress in order to play an important role in the balance inside the plant (Reina-Sanchez et al., 2005). The improvement of the qualitative indicators of fruits when treated with silicon may be due to its role in increasing the leaf area of the plant, which in turn led to a significant reduction in the infestation of fruits with sun blight (Table 5). They significantly reduction of the physiological disorder of Blossom end rot fruits and the production of solid materials necessary for plant growth, in addition to the role of silicon in maintaining hormonal balance within plant tissues, by increasing the concentrations of growth-promoting hormones, and several studies have shown that silicon has the ability to protect Plants are not only from biotic or abiotic stress conditions, but they also play an effective role in improving and regulating the nutritional balance in plants (Waraich et al., 2011). These results are similar to results mentioned by Stamatakis et al. (2003) and Al-Hasnawi (2017) and Soundharya et al. (2019). On the tomato plants, the addition of silicon of various kinds leads to an increase in soluble solids and acidity in the juice of the fruits.

The role of the interaction coefficients in causing an additional significant increase in the characteristics of the specific yield may be due to the cumulative effect, the physiological role of these two components as mentioned previously, and the different response of plants of two cultivar under this study to the interaction treatments is better than the effect of the elements individually.

References

Abdul Rahman, Harith Burhanuddin (2011). Effect of irrigation system and nutrition source on growth. Productivity, physiological damage and mineral content of two hybrids of tomato, PhD thesis, College of Agriculture and Forestry, University of Mosul. Ministry of Higher Education and Scientific Research, Republic of Iraq.

Abu Dahi, Youssef Muhammad (1989). Practical Plant Nutrition, University of Baghdad - House of Wisdom - Ministry of Higher Education and Scientific Research. p. 186.

Abu Dahi, Youssef Muhammad and Muayyad Ahmad Al-Younes (1988). Plant Nutrition Guide, Directorate of Dar Al-Kutub for Printing and Publishing - University of Mosul - Ministry of Higher Education and Scientific Research - Iraq. p. 154.

Adrees M.; Ali, S.; Rizwan, M.; Zia-ur-Rehmen, M.; Ibrahim, M.; Abba, S. F.; Farid, M.; Qayyum, M.F. and Irshad, M.K. (2015). Mechanisms of silicon-mediated alleviation of heavy metal toxicity in plants: A review. Ecotoxicol. Environ. Saf., 119: 186-197.

Al-Ani, A.M.(1978). Postharvist physiology of anjou pear fruit relations between cork spotmineral nutrition , respirition and ethylene evaluation. Ph.D Thesis Oregon State, University Corvallis, Oregen, U. S. A.

Al-Hasnawi, Nasser Jubair Radi (2017). The effect of spraying with silicon on improving the salt tolerance of two cultivars of limited-growing tomato (Lycopersicon esculentum Mill.). PhD thesis, College of Agriculture, University of Basra, Iraq.

Al-Rawi, humbled Mahmoud and Abdul Aziz Muhammad Khalaf Allah (2000). Design and Analysis of Agricultural Operations, University of Mosul, Ministry of Higher Education. House of books for printing and publishing. conductor. Iraq. p. 488.

Avestan, S. ; G. Mahmood, M. Esfahani and A. V. Barker (2021).Effects of nanosilicon dioxide on leaf anatomy, chlorophyll fluorescence, and mineral element composition of strawberry under salinity stress. Journal of Plant Nutrition.www. doi.org.

Cruz Araújo , S. H. ; S. T. de Freitas and P. R. C. Castro (2020). Fruit shape regulates susceptibility of tomato to blossom-end rot. Ac. Scientiarum. Agronomy. 42. www.redalyc.org.

Dawood, Z.A.(1986). Studies in to fruit splitting and quality of sweet cherry (*Prunus avium* L.), tomato (*Lycopersicon esculentum* Mill.) and grape (*Vitis vinifera* L.).Ph.D.theses University of London England .PP238.

Djangsou H.; F. Enrico ; R. Domenico and B. Matteo (2019). Blossom end-rot in tomato (*Solanum lycopersicum* L.): A multi-disciplinary overview of inducing factors and control strategies. Sci. Hort. 249(30): 49-58.

Dris, R. (1998). Effect of pre-harvest calcium treatments on post-harvest quality of apples grown in Finland. Univ. of Helsinki – Department of plant Production Hort. Section – Publication 34- Helsinki Finland.

Epstein, E. (1972). Mineral nutrition of plant : principles and perspectives John Wiley & Sons, New York .USA. 132(2): 158-159.

Esquinas-Alcazar, J. T. (1981). Genetic resources of tomatoes and wid relatives – a global report. International Board for plant Genetic Resources, Food and Agriculture Organization of the United Nations, Rome. p. 65-66.

Guerriero,G.; Hausman, J. and Legay, S. (2016). Silicon and the plant extracellular matrix. Front Plant Sci., 7: 463.

Hassan, Ahmed Abdel Moneim (1989). Basics of vegetable production and technology of open and protected agriculture. Arab House for Publishing and Distribution. p. 625.

Hecht-Buchholzch, (1979). Calcium diffiency and plant ultrastructure Communion soil. Sci. and Plant Analysis., 182(10): 76-81.

Hoffmann, J. ; B. Roberto, H. Jean-Francois and G. Guerriero. (2020). A Review on the Beneficial Role of Silicon against Salinity in Non-Accumulator Crops: Tomato as a Model.

Envir. Res. and Innovation Department, L. Inst. of Sci. and Techno. 10(9) 1284-1288.

Kemble J. and Sikora E. (2020). Blossom-End Rot in Tomatoes: Causes and Prevention. Alabama Cooperative Extension System. ANR – 1059.

Liang, Y.C.; Su, W. C.; Zhu, Y.-G. and Christie, P. (2006). Mechanisms of silicon mediated alleviation of abiotic stresses in higher plants: a review. Environ. Pollut., 147:422–428.

Lu, C.; Qiu, N.;Wang, B. and Zhang, J. (2003).Salinity treatment shows no effects on photosystem II photochemistry, but increases the resistance of photosystem II to heat stress in halophyte Suaeda salsa. J. Exp. Bot., 54(383):851- 860.

Matichenkov, E.A.; Bocharnikova, D.V.; Calvert, G.H. and Snyder. (2000).Comparison study of soil silicon status in sandy soils of south Florida. Soil Crop Sci. Soc. Florida Proc., 59:132–137.

Matlob, Adnan Nasir, Izzeldin Sultan Muhammad and Karim Salih Abdoul (1989). Vegetable production, part two. The second edition, pp. 41-67 - Dar Al-Kutub Establishment for Printing and Publishing - Ministry of Higher Education and Scientific Research / Iraq.

Nakata, P.A. (2003) Advances in our understanding of calcium oxalate crystal formation and function inplants. Plant Sci. 164:901–909.

Ranganna , S. (1977). Manual of Analysis of Fruit and Vegetable Products. The Mc Graw-Hill Publishing company limited- New Delhi, pp. 63.

Reina-Sánchez A.; Romero-Aranda, R. and Cuartero, J. (2005). Plant water uptake and water use efficiency of greenhouse tomato cultivars irrigated with saline water. Estacion Experimental La Mayora, CSIC, 29750. 78(1-2):54-66.

Reitz N.F. and Mitcham E.J. (2021). Validation and demonstration of a pericarp disc system for studying blossom-end rot of tomatoes. Mar 10; 17(1):28.

Riboldi, L. B., Gaziola, S. A., Azevedo, R. A., Freitas, S. T. d., & Castro, P. R. C. (2019). Journal of Plant Growth Regulation , 38(3): 812-823.

Saure, M. C. (2009). Blossom-end rot of tomato-a calcium-or a stress-related disorder, Chamber of Agri. Dorfstr. 17,21647 Moisburg, Germany. 90:193–208.

Siddiqui, S. and F. Bangerth, (2004). Studies on cell wall mediated changes during storage of calcium ifiltrated apples, ISHS Acta. Hort., pp.326.

Soundharya, N., S. Srinivasan, T. Sivakumar and P. R. Kamalkumaran. (2019). Effect of Foliar Application of Nutrients and Silicon on Yield and Quality Traits of Tomato (*Lycopersicon esculentum* L.). Int. J. Pure App. Biosci. 7 (2): 526-531.

Stamatakis, A.; , Papadantonakis, N.; Lydakis-Simantiris, N.; Kefalas, P. and Savvas, D. (2003). Effects of silicon and salinity on fruit yield and quality of tomato grown hydroponically. Acta Horticulutrae, 609:141–147.

Tigchclaar, E. C. and V. L. Folley (1991). Horticultural technology: a case study. HorTechnology 1: 7-16.

Tigchelaar, E.C. (1986) Tomato Breeding, In: Basset, M.J., Ed., Breeding Vegetable Crops. Intercept, Andover, pp. 135-171.

USDA National Nutrient Database for Standard Reference Release 28 (2016). Basic Report 11529, Tomatoes, red, ripe, raw, year round average Report Date: 10:39-41

Vinh T. D., Y. Yoshida, M. Ooyama, T. Goto, K. Yasuba and Y. Tanaka. (2018). Comparative Analysis on Blossom-end Rot Incidence in Two Tomato Cultivarsin Relation to Calcium Nutrition and Fruit Growth. The Hor. Journal. 87(1) 100-114.

Waraich, E. A.; Ahmad, R.; Ashraf, S. and Ehsanullah, M. Y. (2011). Role of mineral nutrition in alleviation of drought stress in plants. Aust. J. Crop Sci., 5(6):764–777.

Watt. B.K. and A.L. Merrill (1963). Composition of foods . U.S. Detp. Agric. Handbook, 8:168-190.

Wei, Y. S. ; Z. B. Zang ; H. B. Shao ; X. Guo ; H. B. Zhao ; Z. Y. Fu and X. J. Hu (2008). Relationship between calcium decoding elements and plant a bioticstress resistance . Int. j. Biol. Sci. 2: 116-125.

Wiersum , L.K. (1966). The calcium supply of fruits and storage tissues in relation to water transport. Acta Hort. 4:33-38.

Zamban. Débora T.; D. Prochnow ; B. O. Caron ;M. Turchetto ; D. Cristina Fontana ; D. Schmidt (2018). Applications of calcium and boron increase yields of Italian tomato hybrids (*Solanum lycopersicum*) in two growing seasons. evista Colombiana de Ciencias Hortícolas. 12(1):82-93.