Effect of some nutrients on growth, Yield and fruit quality of "Wonderful" cultivar pomegranate

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ABSTRACT

Cracking, sunburn and poor coloring of fruit are the main problems facing pomegranate. (*Punica granatum* L.) "Wonderful" cultivar since they play a major role in fruit quality. The current study was carried out during the two successive seasons of 2018 and 2019 on ten years old trees grown in sandy soil in a private orchard located at El Bostan, El- Behera Governorate, Egypt. The effect of B, Ca, Zn, Cu and Mn applied at full bloom stage and 6 weeks after full bloom on "Wonderful" trees was studied. The results indicated that the highest value of vegetative growth was obtained from calcium chloride at 4% and zinc sulphate at 0.4% compared with other treatments. Spraying trees with calcium chloride at 4% and zinc sulphate at 0.4% decreased the percentages of fruit drop, cracking, sunburn and increased significantly yield (kg/ tree) and fruit physical parameters such as fruit weight (g), fruit size (cm^3) and firmness in comparison to other treatments. Fruit biochemical characteristics such as TSS %, ascorbic acid mg /100ml, Anthocyanin and enhancing coloration have been also positively affected by using this treatment compared with other treatments. It might be recommended that foliar spraying "Wonderful" trees with calcium chloride at 4% and zinc sulphate at 0.4% at full bloom stage and 6 weeks after full bloom where, decreased cracking, sunburn and gave the highest values of yield (kg /tree) and fruit quality under the conditions of the experiment in located at El Bostan, El- Behera Governorate, Egypt.

Keywords: pomegranate, Sunburn, coloration, Anthocyanin, nutrients, Cracking

INTRODUCTION

Pomegranate (*Punica granatum* L.) belonging to the Punicaceae family, is one of the favorite table fruits grown in tropical and sub-tropical regions. This plant is native of Iran and is extensively cultivated in the Mediterranean countries like Spain, Morocco, Egypt, Iran and Afghanistan. Wonderful cultivar is the most important pomegranate cultivar grown in El-Behera governorate. According to the Egyptian ministry of agriculture statistics (2018), the total area devoted for pomegranate in Egypt was 80109 Feddan and fruiting area was 76924 Feddan producing about 630000 tons with an average for 8.19 tons /Feddan. El-Behera governorate represents about 60% of the total area and production. Quality assessment of pomegranate fruit is based on important external attributes such as size, shape and color. However, because fruit skin color does not indicate the extent of ripening or its readiness for consumption, internal attributes such as color, total soluble solids and acidity are also considered in assessing readiness for harvest to meet market requirements (Kader, 2006 and Holland *et al*., 2009). Wonderful pomegranate confronts a lot of serious problems such as fruit cracking, sunburn, lack of coloration in the appropriate color of the peel and pulp and lowest average of yield tons / Feddan.

Fruit cracking is one of the main problems facing the pomegranate producers. It resulted in huge losses to farmers by reducing the total yield up to 30- 50%. It also resulted in a significant deterioration in fruit quality which in turn led to a non-marketable yield (Bankar and Prasad 1992, Elsalhy 1996 and Singh and Kingsly 2006). The factors associated with fruit cracking might be high evapotranspiration, low relative air humidity (RH), water imbalance and sharp temperature fluctuation in day and night during fruit growth and development (Abdelrahman, 2010).

sunburn occurs as well mainly where air temperature and the number of sunny hours are high during the ripening period. Sunburn also occurs when cool or mild weather is abruptly followed by hot, sunny weather. Severe sunburn alters the cuticle even more, and damages both the epidermal and sub epidermal tissues. Cell walls get thicker. Intercellular phenols increase, and the structures of plastids and thylakoids change (Barber and Sharpe, 1971; Andrews and Johnson, 1996, 1997). Sadeghzadeh (2013) reported that foliar spray of zinc as sulfate reduced percent cracking besides improving fruit yield probably due to its effect on water uptake and transport besides influencing activities of enzymes involved in protein, carbohydrate and nucleic acid metabolism. Also Hegazi *et al*. (2014) obtained lowest percentage of fruit creaking in Manfaloty and Wonderful pomegranates cultivars with spraying by $CaCl_2$ treatment compared with the control. Lal *et al*. (2011) reported that spraying Jyoti, Dholka, Kandhari, Bedana and G-137 pomegranate varieties with Borax at 50 ppm at 15th May (fruit set) and 15th June (fruit active development stage) decreased percentage of fruit splitting as compared with control. Also, copper plays an indispensable role in regulating several metabolic and physiological processes of plants. It helps in the utilization of iron during chlorophyll synthesis Harris and Lavanya (2016).

Treatments of some nutrients such as (B, Ca, Zn, Cu and Mn) on wonderful pomegranate plants might increase fruiting potential, fruit superiority and marketable fruits. Hence, this work is designed to discover the result of foliar spraying wonderful pomegranate trees with B, Ca, Zn, Cu and Mn on adjusting fruit creaking %, sunburn and increasing vegetative growth, Yield, fruit Physical and Chemical Characteristics.

MATERIALS AND METHODS

This study was carried out during the two consecutive seasons of 2018 and 2019 on 10 - years old “Wonderful” pomegranate trees grown in sandy soil in a private orchard at El Bostan, El- Behera Governorate, Egypt, “Wonderful” pomegranate trees. The trees planted at 3 × 4 meters of spacing. All trees are irrigated using drip irrigation system. The chosen trees for the experimentation were similar in vigor and subjected to the same cultural practices that followed in the farm. The tested trees were sprayed with B, Ca, Zn, Cu and Mn. They studied their effects on vegetative growth, yield, fruit Physical and chemical characteristics of “Wonderful” pomegranate trees at full bloom stage and 6 weeks after full bloom for the two seasons to study their effects on growth, fruit set, fruit yield / tree, cracking, sunburn, physical and chemical properties of fruits.

The treatments:

B, Ca, Zn, Cu and Mn were applied individually at full bloom stage and 6 weeks after full bloom as foliar spray on the trees as follows:

T1: Control (the trees were Sprayed with water only).

T2: Boric acid at concentration 0.5%.

T3: Boric acid at concentration 1%

T4: Calcium chloride at concentration 2%

T5: Calcium chloride at concentration 4%

T6: Zinc sulphate at concentration 0.2%

T7: Zinc sulphate at concentration 0.4%

T8: Copper sulphate at concentration 0.2%

T9: Copper sulphate at concentration 0.4%

T10: Manganese sulphate at concentration 0.2%

T11: Manganese sulphate at concentration 0.4%

A complete randomized block design was adopted in this experiment with 11 treatments where each treatment had three replicates with three trees per treatment. Each tree was received 7 L of the applied solution plus 5cm per liter of 20 to avoid the surface tension except those of control treatment which sprayed with water only

Measurements:

Vegetative growth

Shoot length (cm.):

Twenty shoots/tree were devoted from the beginning of growth measure the shoot length (cm) after it stopped increasing in growth

Number of leaves/ shoots:

Number of leaves/ shoots were recorded at cessation of growth of each season on Twenty shoots per tree

Leaf area (cm^2):

Leaf area (cm) was measured by using the following equation as mentioned by Ahmed and Morsy (1999) Leaf area = 0.41 (Length of leaf x Width of leaf) +1.83 =….. cm

Canopy volume (cm^3):

Tree height and width were measured in Oct. of each season to calculate canopy volume according to Turrel (1946) using the following formula:

Canopy volume = $0.5236 \times HD^2$

where H = tree height and D = tree width

The fruiting: -

Fruit set percentage

Four branches (two years old) similar in growth were chosen, one branch in each original direction and twelve shoots per each main branch were tagged at the balloon stage of the flower. At blooming, all opened flowers/ shoot was counted. After the end of fruit set, the number of fruit set was recorded and fruit set percentage was calculated by using Hifny *et al*. (2013) equation.

Initial fruit set % **=** (Total No. of set fruits /shoot)/ (Total No. of opened flowers/shoot)× 100

Retained fruits percentage:

Number of retained fruits were counted at harvest and calculated by using Hifny *et al*. (2013) equation:

Retained fruits % **=** (No. of retained fruits at harvest/shoot)/ (No. of initial set fruits/shoot) ×100

Fruit drop percentage:

It was recorded according to Hifny *et al*. (2013)

Fruit drop% **= (**No. of fruits at fruit set - No of retained fruits at harvest)/ **(**No. of fruits at fruit set) x 100

Yield:

Harvesting achieved on (5^{th} October for each season), yield (Kg/tree) was recorded.

Yield increase than control (%)

Yield increment than untreated treatment percentage was calculated by using Abdelnaby *et al*. (2019) equation.

Yield increase than control (%) = (Fruit yield (kg) /treatment - Fruit yield (kg)/ control)/ (Fruit yield (kg)/ control) **×**100

Fruit cracking

Percentage of fruit cracking / tree was calculated in three stages (15 days before harvest time, at harvest time and 15 days after harvest time) by using Elakkad et al. (2016) equation

Fruit cracking = No. of cracked fruits/ Total No. of fruits x 100

Sunburn

At harvest time, the number of fruits per tree in each treatment were counted and also each fruit was visually rated depending on the severity of damage by sunburn and calculated as a percentage relative to the total number of fruits on the tree by the following equation: Hegazi et al. (2014)

Sunburn (%) = No. of Sunburn fruits/ Total No. of fruits x 100

Marketable and Unmarketable fruits

according to Hegazi *et al*. (2014)

Marketable fruits%= Total N. of fruits – (No. of cracked + sunburn fruits) x 100.

Unmarketable% **=** (No. of cracked + sunburn fruits)/ (Total No. of fruits) x 100

Fruit physical characteristics:

At harvest, samples of fifteen fruits of each tree replicated were devoted to determine the following fruit characteristics: Fruit weight (g), fruit size (cm^3) fruit length (cm), fruit diameter (cm). fruit firmness (g/cm^2) by using a digital pressure tester (g/cm^2), Peel thickness (cm) and Juice volume cm^3

Fruit biochemical characteristics:

Total soluble solids percentage (TSS %).

It was estimated by abbe digital refractometer, according to A.O.A.C. (2000)

Total acidity percentage.

It was determined as citric acid by titration with a solution of 0.1 N., Na OH, using phenolphthalein as an indicator according to A.O.A.C. (2000). The results were calculated as gm. per 100 ml of juice.

Total soluble solids/ Acid ratio.

It was determined as the following equation:

Total soluble solids/ Acid ratio = TSS (%) / Total acidity (%).

Ascorbic acid (Vitamin C) content.

The amounts of Ascorbic acid in juice samples were determine by the use of 2,6-dichlorophenol indophenol dye and 0.2% oxalic acid as a substrate and 5 ml. of filtered aliquot. It was calculated as mg/ 100 ml. of juice as reported by Ruck (1969).

Total anthocyanin in peel and juice of fruit

Peel anthocyanin content (mg/ 100 g) was assessed according to the method of Fuleki and Francis (1968). Total anthocyanin in juice of fruit was determined according to Ranganna (1979).

The color (hue angle).

It was determined by using a Minolta colorimeter type (CR-400/410) for the estimation of a, b and hue angle (h^o). Hue angle (h^o = arc tan b^*/a^*) determines the red, yellow, green, blue, purple, or intermediate colors between adjacent pairs of these basic colors. Hue angle (0^o = red-purple, 90^o =

yellow, 180°=bluish-green, 270°= blue), as described by McGuire (1992).

Statistical analysis:

A completely randomized block design was followed and the results were statistically analyzed using F-value test. The means were compared by L.S.D at the level of 5% probability according to Snedecor and Cochran (1980). The obtained data were calculated using (COSTAT) program according to Stern (1991)

RESULTS AND DISSCTION

Effect of foliar spraying with B, Ca, Zn, Cu and Mn on vegetative growth

The data in Table (1) illustrated that the application of some nutrients (B, Ca, Zn, Cu and Mn) on Wonderful pomegranate gave a significantly increased of shoot length (cm) compared with control treatment in both studied seasons. The highest length of shoot was obtained from calcium chloride at 4% followed in descending by zinc sulphate at 0.4% then zinc sulphate at 0.2% and calcium chloride 2%. On the other hand, the lowest length of shoot was obtained from "control" during 2018 and 2019 seasons. The results are in agreement with those of other workers such as Sutanu *et al*. (2017) who found that foliar application of Ca at 3 % + B at 0.25 % in *Punica granatum L*. increased shoot length as compared with control. Also, Ibrahim (2013) found that foliar application of olive with $Znso_4$ at 30 ppm on 21 April increased shoots length (cm) as compared with the control. Shoot length increased due to treatments with calcium which was playing an important role in the component of plant tissue and took part in the protection of plant cells Elmer *et al*. (2007). The spraying of $Znso_4$ plays also an important role to activate up to 300 enzymes such as Peptidase, Proteinase, Enolase and also needs a plant in the formation of the amino acid Tryptophan, which consists of hormone indole acetic acid (IAA) which is essential for cell elongation Barker and Pilbeam (2007).

It is obvious from Table (1) that, the number of leaves per shoot increased by all treatments (B, Ca, Zn, Cu and Mn) in both seasons as compared with control. The largest number of leaves per shoot was obtained from calcium chloride at 4% followed descending by zinc sulphate at 0.4% then zinc sulphate at 0.2% and calcium chloride 2% in the two studied seasons. On the other hand, the lowest length of shoot was obtained from "control" during 2018 and 2019 seasons. The results are in agreement with those of other workers such as Bakeer (2016) which indicated that foliar application of Manfalouty pomegranate trees by $CaCl_2$ at 2% at four times (The first week of March, May, July and September) increased number of leaves as compared with control. Also, Singh *et al*. (2005) observed that the foliar application of zinc (0.25% and 0.5% ZnSO4) at two months from transplanting significantly increased the number of leaves per plant in papaya. The increase in the number of leaves is due to the increase in shoot length resulting from spraying with compounds (B, Ca, Zn, Cu, Mn). Where calcium is important for proper cell division, cell elongation, cell wall development (Ashraf *et al*., 2018). As well as zinc is involved in the synthesis of tryptophan which is a precursor to the synthesis of indole acetic acid, thus increasing tissue growth and development. It has an important role in starch metabolism, acts as a cofactor for many enzymes, and affects photosynthesis reaction, DNA metabolism, and protein biosynthesis. (Alloway, 2008).

Data presented in Table (1) displayed that, there were significant differences between spraying nutrient treatments (B, Ca, Zn, Cu and Mn) on leaf area, whereas, all treatments increased leaf area (cm^2) compared to that of control treatment. Trees treated by calcium chloride at 4% specifically led to significant increase of the largest leaf area followed in descending by zinc sulphate at 0.4% then calcium chloride 2% and zinc sulphate at 0.2%. The results are in agreement with those of other workers such as Alrawi *et al*. (2014) who found that spraying Salemy pomegranate cv., with $Cacl_2$ at 100 ppm in the last week of May and first week of June increased leaf area (cm^2) as compared with control. On the other hand, Hasani *et al*. (2012) suggested that application of $Znso_4$ at 0.3% of pomegranate tree increased leaf area (cm^2) compared with the control. Dickinson *et al*. (2003) reported that the role of zinc in DNA and RNA metabolism, in cell division, and protein synthesis has been documented for many years.

Results in Table (1) showed that there were significant differences between spraying nutrient treatments (B, Ca, Zn, Cu and Mn) on canopy volume (m^3) whereas, all treatments increased canopy volume (m^3) compared to that of control treatment. The highest Canopy volume (m^3) was obtained from calcium chloride at 4% followed descending by zinc sulphate at 0.4% in the two studied seasons. On the other hand, the lowest canopy volume (m^3) was obtained from "control" during 2018 and 2019 seasons. The results are in agreement with those of other workers such as Bakeer (2016) who indicated that foliar application of Manfalouty pomegranate trees at $CaCl_2$ at 2% at four times (The first week of March, May, July and September) increased plant height (m) and plant canopy volume(m3) and leaf area (cm^2) as compared with control. Also, Ibrahim (2013) found that foliar application of olive trees with $Znso_4$ at 30 ppm on 21 April increased Plant height as compared with the control (m) and plant canopy volume(m^3). The increase in the canopy volume(m^3) is due to the increase in shoot length, number of leaves and leaf area (cm^2) resulting from spraying with compounds B, Ca, Zn, Cu and Mn.

It could be concluded that foliar spraying of Wonderful pomegranate trees at full bloom stage and 6 weeks after full bloom with calcium chloride and zinc sulphate stimulated the shoot length, number of leaves per shoot and leaf area as well as canopy volume(m^3) in comparison to the of other foliar treatments or control.

Effect of foliar spraying with B, Ca, Zn, Cu and Mn on fruiting

The results in Table (2) indicated that spraying each B, Ca, Zn, Cu and Mn was able to significantly increase the percentages of initial and fruit retention and decrease fruit drop as compared with that of untreated trees (control) in a consistent manner in both seasons. Results also showed that the highest percentages of initial fruit set and fruit retention of the first and second seasons were obtained from spraying trees with calcium chloride at 4% followed by zinc sulphate at 0.4%. On the other hand, the lowest percentages of initial fruit set and fruit retention were obtained from control. The results are in full agreement with those of other workers such as Ahmed *et al*. (2014) who found that spraying of “Manfalouty” pomegranate trees at the first week of March, May and June with $CaCl_2$ at 2% increased percentages of initial fruit set, fruit retention, number of fruits / trees as compared with control. Also, Parmar *et al*. (2014) found that foliar application of guava tree with zinc sulfate at concentrations (0.2 and 0.4) before blooming increased fruit set%, fruit retention% compared with the control. The role of Ca in stopping the formation of abscission zone between fruit pedicles and bearing branches as well as regulating the activity of enzymes and photosynthesis (Tony and John, 1994; Mignani *et al*., 1995 and Jackman and Stanley, 1995)., Ashraf *et al*. (2013) also indicated that application of zinc improves the citrus fruit yield and this might be due to involvement of zinc in photosynthesis, activation of enzyme systems, protein synthesis and carbohydrate translocation.

The results showed that all treatments significantly decreased fruit drop percentage as compared with the control. The highest fruit drop percentage was obtained from control. On the other hand, the lowest fruit drop percentage of the first and second seasons was obtained from spraying trees with calcium chloride at 4% followed by zinc sulphate at 0.4%. In this line Nijjar (1985) demonstrated that a tentative explanation for the decreased fruit drop percentage due to calcium and zinc sprays may be due to the improvement in the formation of cellulose and lignin. These materials are required for building plant structure or preventing the abscission layer formation and consequently, the reduction in pre-harvest fruit dropping. Yagodin (1990) also reported that zinc plays many important regulatory roles in plant development. It activates many enzymes involved in plant metabolism and enhances the biosynthesis of some organic foods and IAA as well as stimulates cell division, cell enlargement, water absorption and nutrient transport. It is also important for strengthening cell wall and reducing the formation of the abscission zone which leads to decreased fruit drop percentage.

Data in Table (2) displayed clearly that both yield as (kg/tree) and increment percentage in relation to the control have responded significantly to all used treatments as compared with control treatment during the two seasons of study. Furthermore, the greatest statistical values of both yield parameters were resulted from “Wonderful” pomegranate trees being sprayed with calcium chloride at 4% followed by zinc sulphate at 0.4%. On the other hand, the lowest yield as (kg/tree) was obtained from control. This increase in yield as (kg/tree) and increment percentage is due to increased initial fruit set, fruit retention (%), fruit weight and decreased fruit drop (%). These above results agreed with the findings of Sheikh and Manjula (2012) who found that foliar application of pomegranate cultivar ‘Ganesh’ with $CaCl_2$ at 1% at pre-harvest increased yield kg/tree as compared with control. Hamouda *et al*., (2016) reportedas well that foliar spraying Manfalouty pomegranate with Zn at 2000 ppm at mid of March, April and June increased yield kg / tree as compared with control.

We can come to conclusion that foliar application with B, Ca, Zn, Cu and Mn at different levels increased initial and fruit retention percentages and yield (kg/tree) in comparison with that of untreated tree (control). The best foliar application which gave the highest values was obtained with calcium chloride at 4% compared with control and other treatments.

Effect of foliar spraying with B, Ca, Zn, Cu and Mn on fruit cracking, sunburn, marketable and unmarketable fruits:

Fruit cracking

The results in Table (3) indicate that the percentage of fruit cracking / tree was calculated during three stages 15 days before harvest time, at harvest time and 15 days after harvest time. The general trend of the results was to increase the percentage of cracking with the advancement of the fruits in ripening, but this percentage in the increase was low due to the use of B, Ca, Zn, Cu and Mn during the three stages. The 1st stage (15 days before harvest time), 2nd stage (at harvest time) and 3rd stage (15 days after harvest time) all treatments in general significantly decreased percentage of fruit cracking / tree as compared to the control during the two studied seasons. The highest fruit cracking percentages during the three stages in the first and second seasons were obtained from control. In this respect, the lowest significant fruit cracking percentage during the three stages (15 days before harvest time, at harvest time and 15 days after harvest time) was obtained from calcium chloride at 4% followed by zinc sulphate at 0.4%, copper sulphate at 0.4% and calcium chloride at 2% in both studied seasons. The results confirmed by Randhawa *et al*. (1958) who reported that cracking occurs after heavy rainfalls, followed by a period of drought. Nutrients like calcium, zinc, copper, molybdenum and manganese are involved in some physiological processes during the fruit growth period, and their deficiency results in fruit cracking. The previous positive action of calcium on reducing fruit splitting of Wonderful pomegranate trees might be attributed to their important roles in strengthening cell wall through building calcium pectates in the middle lamella as well as stabilization of membrane systems and strengthening the bonds between epidermal and other fruit cells. Calcium is also responsible for reducing the abscission zone formation among fruits and branches as well as regulating the mechanisms of photosynthesis and proteins (Poovaiah, 1986; Tony and John, 1994 and Jackman and Stanley, 1995). The beneficial effect of Ca in promoting the biosynthesis of sugars and plant pigments as well as checking the uptake of water was accompanied with enhanced maturity and improved fruit quality (Yagodin, 1990 and Mengel *et al*., 2001). The beneficial effects of zinc on controlling water absorption and nutrient uptake as well as enhancing the biosynthesis of the natural hormone namely IAA surely reflected on reducing fruit cracking %, Yagodin (1990). Moreover, zinc is responsible for strengthening cell wall and reducing the formation of the abscission zone (Mengel *et al*., 2001).

Effect of foliar spraying with B, Ca, Zn, Cu and Mn on sunburn, marketable and unmarketable fruits

The results in Table (4) indicate that the percentage of sunburn, marketable and unmarketable fruits. Sunburn injury is common on fruits due to high solar radiation levels and air temperatures and low relative humidity. Excess absorbed energy is the greatest contributor to cell death and sunburn. The incidence and severity of sunburn depends upon climatic factor, cultivars, hormonal, nutritional and soil moisture (Schrader *et al*., 2003). Sunburn can be prevented only by shutting off direct sunlight, or by wrapping the fruit with paper, or by other means, but these methods are not practical because of high labor costs, and they have not come into widespread use (Sadamatsu, 1982).

The results in Table (4) showed that all treatments in general significant decreased percentage of sunburn and unmarketable fruit as compared to the control during 2018 and 2019 seasons. In this respect, all treatments in general significantly increased percentage marketable fruit as compared with control in a consistent manner in both seasons. The lowest significant percentage of sunburn and unmarketable fruit was obtained from calcium chloride at 4% followed by calcium chloride at 2%, zinc sulphate at 0.4% and zinc sulphate at 0.2% in the first and second seasons. So, the highest percentage of marketable fruit was obtained from these treatments (calcium chloride at 4% followed by calcium chloride at 2%, zinc sulphate at 0.4% and zinc sulphate at 0.2%). The results confirmed by Glenn *et al*. (2002) who reported that crimson seedless grapevines treated with plant protection as $CaCo_3$ were less prone to sunburn damage than untreated ones and this is due to reducing both fruit temperature and exposure to ultraviolet. Also, Ahmed *et al*. (2011) found that $CaCo_3$ stimulated plant metabolism through enhancing photosynthesis and formation of plant pigments in favor of enhancing quality of the berries.

It is concluded that foliar application with B, Ca, Zn, Cu and Mn at different ranges increased marketable fruits and decreased fruit cracking (%) at different stages, sunburn (%) and unmarketable fruits in comparison with that of untreated trees (control). The best foliar application was calcium chloride at 4 % compared with the control and other treatments.

Effect of foliar spraying with B, Ca, Zn, Cu and Mn on some fruit physical characteristics

Average fruit weight and fruit size

Data in Table (5) showed the effect of spraying with B, Ca, Zn, Cu and Mn on average fruit weight and fruit size of Wonderful pomegranate cultivar in the two studied seasons. The maximum effect of average fruit weight (g) and size (cm^3) with using calcium chloride at 4% followed by zinc sulphate at 0.4% in both seasons. This significantly increased fruit weight and size due to application of Ca which is important to every plant for their growth and development and is involved in activating the enzymes, inducing water movement and salt balance in plant cells, and also activating K to control the process of opening and closing of stomata (Hepler 2005). Yogeratnam and Greenham (1982) also reported that applying zinc to the trees might improve fruit quality such as fruit size by enhancing formation and translocation of carbohydrates and carbohydrate enzymes. Also, zinc plays many important regulatory roles in plant development through activating different enzymes, the biosynthesis of organic foods, cell division and cell enlargement (Yagodin, 1990). In this line Badawy *et al*. (2019) found that foliar application of "Manfalouty" pomegranate with $CaCl_2$ at 2% twice on mid of June and August increased fruit weight as compared with control. Also, Abdelrhman *et al*., (2017) found that spraying of Manfalouty Pomegranate trees at the first week of March (growth start setting), May and June with $ZnSo_4$ at $10gL^{-1}$ increased fruit weight (g.) as compared with control.

Fruit length (cm) and fruit diameter (cm).

Table (5) display obviously that different applied treatments (B, Ca, Zn, Cu and M) significantly increased fruit length (cm) and diameter (cm) compared to the control treatment for the two seasons. However, calcium chloride at 4% significantly increased fruit length (cm) and fruit diameter (cm), statistically followed by second significantly increased with using zinc sulphate at 0.4 during both 2018 and 2019 seasons. The increase of fruit length (cm) and diameter (cm) might be due to both the Ca and Zn ability in the division and elongation of the fruit cells. In this respect, Alloway (2008) reported that Zn Involvement in the synthesis of tryptophan which is a precursor of indole acetic acid synthesis, consequently it increased tissue growth and development. It has important role in starch metabolism, and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis. The present result is in full agreement with that reported by Elakkad *et al*. (2016) who found that foliar application of Manfalouty pomegranate trees with $CaCl_2$ at 80 ml /l at two months after fruit set increased fruit height(cm) and fruit diameter as compared with control. Also, Hamouda *et al*. (2016) reported that foliar spraying Manfalouty pomegranate with Zn at 2000 ppm at mid of March, April and June increased fruit length and diameter(cm).

Fruit firmness (g/cm^2), Peel thickness (cm) and Juice volume (cm^3)

Data in Table (5) also showed that the highest fruit firmness (g/cm^2) of the first and second seasons which were obtained from calcium chloride at 4% followed by calcium chloride at 2%, zinc sulphate at 0.4% and zinc sulphate at 0.2%. In contrast, the lowest fruit firmness (g/cm^2) of the first and second seasons was obtained from control. The increase of fruit firmness (g/cm^2) might be due to the fact that calcium has an essential role in plant structure and development. Before being absorbed by plants, calcium regulates the uptake of ions and adjusts the pH of soil (Quintero, 1991). Once in the plant system, calcium participates in polarity growth, secretion, hormonal actions, cell division, cationic transport, photosynthesis, gene expression, and many other processes. Most of these functions are achieved by interacting with calcium-related proteins such as Ca-calmodulin which is the best known calcium-binding proteins (White and Broadley, 2003). In addition to these functions, about 60% of calcium is found the cell wall where pectic substances are abundant. It is known to perform a crucial role in determining cell structure and integrity, cell-to-cell adhesion, and tissue coherence (Poovaiah *et al*., 1988). Spraying of 1 g micronutrients + 0.3 ml P/L (phosphoric acid/liter) at full bloom + fruit set significantly increased fruit firmness as compared with control (Singh and Usha 2001). Also, Calcium chloride ($CaCl_2$) has influence on the physical characteristics of fruits. In this respect, (Matas *et al*., 2009; Demuth and Sundrud 2012) reported that Calcium plays an important role in regulating the metabolism in apple fruit, and adequate calcium concentration maintains fruit firmness, delays fruit ripening, and internal breakdown.

Data in Table (5) also showed that the highest Peel thickness (cm) of the first and second seasons was obtained from calcium chloride at 4% followed by zinc sulphate at 0.4%. The present result is in full agreement with that reported by Karemera *et al*. (2014) who showed that the physical characteistic of fruits, Totapuri cv. recorded significantly higher fruit thickness when trees were sprayed with 1.50 % $CaCl_2$ at 30 days before harvest. The increased Peel thickness (cm) may be due to calcium chloride which could be attributed to its effects in influencing formation and changes of carbohydrates and carbohydrate enzymes, others reasons might be the reduction of abscission and the calcium influence in maintaining the middle lamella cells. The results obtained in the present investigation can be compared to those obtained by Wahdan *et al*. (2011).

Data in Table (5) also showed that the application of some spraying nutrients (B, Ca, Zn, Cu and Mn) gave significantly increase of volume of “Wonderful” fruit juice (cm^3) compared with that of control in both studied seasons. The highest Juice volume (cm^3) of the first and second seasons was obtained from zinc sulphate at 0.4% followed by calcium chloride at 4%. The present result is in full agreement with that reported by Hasani *et al*. (2012) who found that foliar application of pomegranate tree with $Znso_4$ at both levels (0.3) increased juice % content as compared with control. On the other hand, Ahmed *et al*., (2014) found that spraying of Manfalouty Pomegranate trees at the first week of March, May and June with $CaCl_2$ at 2 % increased juice volume as compared with control.

It is concluded that foliar application with B, Ca, Zn, Cu and Mn at different ranged increased fruit weight, fruit size, fruit length, fruit diameter, fruit firmness (g/cm^2), Peel thickness (cm) and Juice volume (cm^3) in comparison with that of untreated trees (control). The best foliar application was calcium chloride at 4 % compared with the control and other treatments.

Effect of foliar spraying with B, Ca, Zn, Cu and Mn on fruit biochemical characteristics.

Percentages of total soluble solids, total acidity and TSS/ Acid ratio.

Table (6) showed that in both seasons, all treatments increased total soluble solids TSS (%) as compared with the control. The highest values of T.S.S (%) were obtained from zinc sulphate at 0.4% followed by descending calcium chloride at 4%. Meanwhile, the lowest values of TSS (%) in both seasons were obtained from control. These results are in line with those obtained by Hasani *et al*. (2012) who found that foliar application of pomegranate tree with $Znso_4$ at 0.3 % increased TSS% and juice content as compared with control. Also, Badawy *et al*. (2019) found that foliar application of "Manfalouty" pomegranate with $CaCl_2$ at 2% twice on mid of June and August increased T.S.S (%) as compared with control. Moreover, Alrawi *et al*. (2012) reported that the increase in the percentage of total soluble solids when spraying Zn may be due to the role of these elements in increasing activities of the vegetative growth, then absorb nutrients. Also, the improvement in quality of fruit might be due to the fact that micronutrients directly play an important role in plant metabolism as zinc is needed in enzymatic reaction like hexokinase, formation of carbohydrate and protein synthesis (Pamila *et al*., 1992).

Table (6) showed that in both seasons all treatments decreased total acidity percentages as compared with the control. The highest values of total acidity (%) in both seasons were obtained from control. Meanwhile, the lowest values of total acidity (%) in both seasons were obtained from zinc sulphate at 0.4% followed by zinc sulphate at 0.2%, calcium chloride at 4% and calcium chloride at 2%. These results are in line with those obtained by Hamouda, *et al*. (2016) who reported that foliar spraying Manfalouty pomegranate with Zn at 2000 ppm at mid of March, April and June decreased total acidity % as compared with control. As well as, Elakkad *et al*. (2016) found that foliar application of Manfalouty pomegranate trees with $CaCl_2$ at 80 ml /l at two months after fruit set decreased total acidity as compared with control.

Table (6) showed that the highest values of TSS/ acidity in the first and second seasons were obtained from zinc sulphate at 0.4%

followed in descending by zinc sulphate at 0.2%, calcium chloride at 4%. Meanwhile, the lowest values of TSS/ acidity were obtained from control. The increase in TSS/Acidity is due to the increase in TSS and the decreased total acidity. These results are in line with those obtained by Abdelrhman *et al*. (2017) who found that spraying of Manfalouty Pomegranate trees at the first week of March (growth start setting), May and June with $ZnSo_4$ at 10gL-1 increased TSS. % and decreased total acidity as compared with control. Also, Badawy *et al*. (2019) found that foliar application of "Manfalouty" pomegranate with $CaCl_2$ at 2 % twice increased T.S.S and decreased total acidity (%) as compared with control.

Ascorbic acid (VC) content (mg/100ml of fruit juice)

Data in tables (6) showed that all treatments increased Vitamin C when compared with that of control in the two studied seasons. The highest values of Vitamin C were obtained from zinc sulphate at 0.4% followed by Zinc sulphate at 0.2%, calcium chloride at 4% and Calcium chloride at 2% Whereas, the lowest values of vitamin C were obtained from the control. These results are in line with those obtained by Hamouda *et al*. (2016) who reported that foliar spraying Manfalouty pomegranate with Zn at 2000 ppm at mid of March, April and June increased VC as compared with control. Also, Amro (2015) found that foliar application of Valencia orange with $Znso_4$ at 0.4% three times the 1st spray was after fruit set, the 2nd spray was at the mid of June and 3rd was at the mid of August increased VC in comparison to the control. Similarly, Elakkad *et al*. (2016) found that foliar application of Manfalouty pomegranate trees with CaCl2 at 80 ml /l at two months after fruit set increased VC as compared with control.

Total anthocyanin mg/100ml in juice and peel

Anthocyanins are a group of natural pigments responsible for the red-blue colors of many fruits and vegetables. They are of interest because in addition to their use as natural colorants, they also have important effect on human health (Fischer *et al*., 2013; Türkyilmaz, 2013; Radunic *et al*., 2015). Data in Tables (6) showed that all treatments increased Anthocyanin of juice mg/100ml when compared with that of control in the two seasons. The highest values of Anthocyanin mg/100ml of juice in 2018 season were obtained from zinc sulphate at 0.4% followed by calcium chloride at 4%, Zinc sulphate at 0.2% and manganese sulphate at 0.4%. Whereas, the highest values of Anthocyanin mg/100ml of juice in 2019 season were obtained from zinc sulphate at 0.4% followed by calcium chloride at 4%, manganese sulphate at 0.4% and manganese sulphate at 0.2%. On the other hand, the lowest values of Anthocyanin mg/100ml of juice were obtained from the control in 2018 and 2019 seasons.

Also, Data in tables (6) showed that all treatments increased Anthocyanin mg/100g fruit peel when compared with that of control in the two seasons. The highest values of Anthocyanin mg/100g of fruit peel in 2018 season were obtained from zinc sulphate at 0.4% followed by zinc sulphate at 0.2%, calcium chloride at 4%, and calcium chloride at 2%. Whereas, the highest values of Anthocyanin mg/100ml of fruit peel in 2019 season were obtained from zinc sulphate at 0.4% followed by zinc sulphate at 0.2%, calcium chloride at 4%, and manganese sulphate at 0.4%. on the other hand, the lowest values of Anthocyanin mg/100 g fruit peel were obtained from the control in 2018 and 2019 seasons. These results are in line with those obtained by Hamouda *et al*. (2016) who reported that foliar spraying of Manfalouty pomegranate with Zn at 2000 ppm at the mid of March, April and June increased anthocyanins mg/L and decreased total acidity % as compared with control. Also, Elakkad *et al*. (2016) found that foliar application of Manfalouty pomegranate trees with $CaCl_2$ at 80 ml /l at two months after fruit set increased anthocyanins mg/L as compared with control. Similarly, Badawy *et al*. (2019) found that foliar application of "Manfalouty" pomegranate with $CaCl_2$ at 2% twice on the mid of June and August increased anthocyanin as compared with control. Hamouda *et al*., (2016) reported that foliar spraying Manfalouty pomegranate with Mn at 1600 ppm at mid of March, April and June increased anthocyanins mg/L and decreased total acidity % as compared with control.

Hue angle

As shown in table (6), the hue angle of Wonderful cv., fruits were the lowest with all treatments in the two studied seasons. respectively. However, the highest hue angle was recorded control treatment. The result in table (6) showed that the highest hue angle in peel and arils was obtained from control in both seasons. On the other hand, the lowest hue angle in peel and arils was obtained from zinc sulphate at 0.4% followed by calcium chloride at 4% and Calcium chloride at 2% in the two studied seasons. The decrease of hue angle means that the external color developed from green to red as a result of the chlorophyll pigments decrease (McGuire, 1992).

We can come to conclusion that foliar application of "Wonderful" pomegranate with B, Ca, Zn, Cu and Mn at different concentrations significantly increased TSS (%), TSS/ acid ratio and VC (mg/100ml) of fruit juice, Anthocyanin mg/ml (juice) and mg/100g (peel) and the color in comparison with that of untreated tree (control). The best foliar application was obtained with zinc sulphate at 0.4% followed by calcium chloride at 4%

CONCLUSION

We can come to concluded that foliar application of "Wonderful" pomegranate with Ca and Zn at different concentrations significantly increased the vegetative growth, fruiting, fruit quality and decreased fruit cracking, sunburn as compared with control.

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Table 1. Effect of some nutrients on vegetative growth [shoot length, number of leaves / shoots, leaf area (cm^2) and canopy volume (m^3)] of "Wonderful" trees in 2018 and 2019 seasons.

Character.	Shoot length (cm)		Number of leaves / shoot		Leaf area (cm^2)		Canopy volume(m^3)	
	season							
Treatment	2018	2019	2018	2019	2018	2019	2018	2019
Control	18.28	19.66	20.47	19.47	4.27	5.18	7.33	8.04
Boric acid at 0.5%	24.76	26.09	23.77	25.10	5.65	6.66	8.49	9.25
Boric acid at 1%	28.07	29.40	26.01	28.01	7.27	7.78	9.90	10.57
Calcium chloride at 2%	30.28	32.94	27.40	30.97	8.75	9.01	11.66	12.17
Calcium chloride at 4%	38.10	39.77	33.18	38.11	11.25	11.94	12.94	13.81
Zinc sulphate at 0.2%	32.13	34.80	28.15	31.52	8.46	8.77	11.94	12.21
Zinc sulphate at 0.4%	35.21	36.21	30.92	35.92	9.74	10.18	12.52	13.05
Copper sulphate at 0.2%	28.61	29.61	26.35	28.61	6.87	6.90	9.89	10.26
Copper sulphate at 0.4%	29.70	31.26	27.10	29.84	7.38	8.00	10.09	10.63
Manganese sulphate at 0.2%	27.08	27.41	26.37	26.97	8.12	8.83	8.82	9.48
Manganese sulphate at 0.4%	30.08	32.41	28.40	30.06	8.59	8.70	11.24	12.25
LSD at 5%	1.98	1.50	1.00	1.22	0.19	0.39	0.12	0.24

Table 2. Effect of some nutrients on fruiting of "Wonderful" trees in 2018 and 2019 seasons.

Character.	Initial fruit set (%)		Fruit retention (%)		Fruit drop (%)		Yield (kg/tree)		Increase (%) in yield than control.	
	season									
Treatment	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Control	55.30	58.64	58.27	61.93	41.73	38.07	50.79	55.45	0.00	0.00
Boric acid at 0.5%	60.27	64.94	78.48	80.81	21.52	19.19	67.73	72.32	33.41	30.40
Boric acid at 1%	65.47	70.14	73.77	74.44	26.23	25.56	64.06	68.82	26.18	24.12
Calcium chloride at 2%	67.20	73.20	81.37	83.31	18.63	16.69	78.41	84.08	54.41	51.65
Calcium chloride at 4%	71.02	77.69	88.35	87.25	11.65	12.75	98.94	105.84	94.86	90.86
Zinc sulphate at 0.2%	68.31	74.65	84.04	82.44	15.96	17.56	83.65	89.43	64.70	61.28
Zinc sulphate at 0.4%	69.85	75.52	85.89	84.55	14.11	15.45	89.55	96.22	76.41	73.55
Copper sulphate at 0.2%	62.95	66.62	62.29	65.63	37.71	34.37	66.89	72.46	31.75	30.67
Copper sulphate at 0.4%	64.20	69.20	64.15	68.15	35.85	31.85	70.71	75.67	36.22	36.47
Manganese sulphate at 0.2%	60.74	61.40	65.80	70.47	34.20	29.53	73.81	78.47	45.39	41.51
Manganese sulphate at 0.4%	62.93	66.60	67.71	74.05	32.29	25.95	75.19	80.86	48.08	45.83
LSD at 5%	0.77	2.95	1.01	1.54	1.01	1.54	2.00	2.08	7.09	4.19

Table 3. Effect of some nutrients on fruit cracking (%) of "Wonderful" trees in 2018 and 2019 seasons.

Character.	Fruit cracking%					
	2 weeks before harvest time		At harvest time		2 weeks after harvest time	
	season					
Treatment	2018	2019	2018	2019	2018	2019
Control	19.46	17.39	24.63	22.80	29.63	31.62
Boric acid at 0.5%	14.59	13.04	17.12	14.99	21.10	20.54
Boric acid at 1%	12.98	12.34	15.32	14.02	18.29	18.22
Calcium chloride at 2%	11.10	9.89	12.73	10.70	14.51	12.89
Calcium chloride at 4%	7.09	5.72	8.14	6.79	9.24	9.04
Zinc sulphate at 0.2%	11.60	10.98	13.16	12.38	16.14	16.17
Zinc sulphate at 0.4%	9.68	6.78	11.60	8.59	13.73	10.90
Copper sulphate at 0.2%	12.00	11.83	15.18	14.07	17.96	19.99
Copper sulphate at 0.4%	10.97	8.43	13.73	9.92	16.71	11.39
Manganese sulphate at 0.2%	13.62	12.61	15.78	14.95	19.75	20.97
Manganese sulphate at 0.4%	11.98	11.04	15.68	12.47	18.64	16.71
LSD at 5%	1.09	0.47	0.96	0.32	0.84	0.73

Table 4. Effect of some nutrients on sunburn (%), marketable and unmarketable fruits of "Wonderful" trees in 2018 and 2019 seasons.

Character	Sunburn (%)		Marketable fruits		Unmarketable fruits	
	season					
Treatment	2018	2019	2018	2019	2018	2019
Control	32.89	27.23	42.48	49.97	57.52	50.03
Boric acid at 0.5%	28.11	24.26	54.77	60.80	45.23	39.20
Boric acid at 1%	26.51	19.82	58.17	66.03	41.83	33.97
Calcium chloride at 2%	14.46	10.77	72.81	78.39	27.19	21.61
Calcium chloride at 4%	12.42	6.83	79.44	86.42	20.56	13.58
Zinc sulphate at 0.2%	16.63	12.77	70.21	74.74	29.79	25.26
Zinc sulphate at 0.4%	16.28	12.13	72.12	79.36	27.88	20.64
Copper sulphate at 0.2%	25.39	18.76	59.43	67.23	40.57	32.77
Copper sulphate at 0.4%	22.83	15.97	63.44	74.12	36.56	25.88
Manganese sulphate at 0.2%	19.75	14.61	64.46	70.35	35.54	29.65
Manganese sulphate at 0.4%	17.73	12.92	66.59	74.59	33.41	25.41
LSD at 5%	1.42	0.42	1.70	0.35	1.70	0.35

Table 5. Effect of some nutrients on some fruit physical characteristics of "Wonderful" pomegranate in 2018 and 2019 seasons.

Character. Treatment	Fruit weight (g)	Fruit size (cm^3)	Fruit length (cm^2)	Fruit diameter (cm^2)	Fruit firmness. g/cm^2	Peel thickness (cm)	Juice volume cm^3
Season 2018							
Control	361.31	321.09	7.80	7.37	403.53	0.43	113.14
Boric acid at 0.5%	365.83	331.15	8.50	7.87	423.19	0.47	122.23
Boric acid at 1%	371.69	369.94	9.03	8.23	440.86	0.54	129.27
Calcium chloride at 2%	374.22	378.20	9.77	8.70	491.19	0.69	136.15
Calcium chloride at 4%	382.81	412.20	10.83	9.23	521.81	0.74	143.68
Zinc sulphate at 0.2%	373.13	363.26	9.50	8.37	467.58	0.60	138.66
Zinc sulphate at 0.4%	379.91	392.06	9.97	8.70	480.87	0.65	144.99
Copper sulphate at 0.2%	367.38	329.14	8.70	7.87	428.88	0.52	125.81
Copper sulphate at 0.4%	369.26	338.27	9.07	8.10	446.79	0.54	127.27
Manganese sulphate at 0.2%	371.48	320.16	8.70	7.83	422.70	0.54	128.74
Manganese sulphate at 0.4%	372.30	337.04	9.13	8.73	451.94	0.57	129.63
LSD 5%	1.13	3.53	0.18	0.19	2.17	0.008	1.09
Season 2019							
Control	372.65	318.76	8.07	7.17	413.53	0.51	119.83
Boric acid at 0.5%	377.50	350.48	8.60	7.70	437.52	0.56	129.47
Boric acid at 1%	384.69	382.11	9.20	7.93	450.92	0.61	136.43
Calcium chloride at 2%	389.89	391.20	10.23	8.47	507.36	0.73	144.4
Calcium chloride at 4%	400.14	435.87	10.67	8.93	540.45	0.78	151.57
Zinc sulphate at 0.2%	386.13	381.26	9.73	8.10	487.38	0.65	146.23
Zinc sulphate at 0.4%	396.24	412.72	10.40	8.57	499.20	0.70	153.87
Copper sulphate at 0.2%	379.28	347.47	8.97	7.70	443.55	0.58	133.03
Copper sulphate at 0.4%	380.49	355.93	9.57	7.90	458.15	0.62	132.3
Manganese sulphate at 0.2%	382.81	357.49	8.83	7.63	433.04	0.60	133.43
Manganese sulphate at 0.4%	383.63	359.71	9.40	8.33	462.47	0.64	135.07
LSD 5%	0.88	1.76	0.09	0.11	1.70	0.009	1.58

Table 6. Effect of foliar spraying with some nutrients on fruit biochemical characteristics and hue angle of Wonderful pomegranate in 2018 and 2019 seasons.

Character. / Treatment	TSS (%)	Total acidity (%)	TSS/ Acid ratio	VC mg /100ml of fruit juice	Anthocyanin mg/100ml of Juice	Anthocyanin mg /100g of Peel	Hue angle Peel	Hue angle Arils
season 2018								
Control	15.17	1.95	7.79	23.23	18.67	15.20	359.81	359.20
Boric acid at 0.5%	15.97	1.71	9.34	26.67	20.50	16.10	351.60	344.57
Boric acid at 1%	16.53	1.63	10.16	29.10	21.83	16.73	347.50	340.60
Calcium chloride at 2%	16.97	1.55	10.95	32.03	23.63	17.57	341.53	333.90
Calcium chloride at 4%	17.53	1.45	12.12	33.90	26.00	19.30	337.27	330.83
Zinc sulphate at 0.2%	17.50	1.40	12.50	36.17	25.30	20.50	341.60	337.07
Zinc sulphate at 0.4%	18.63	1.36	13.70	38.00	28.57	21.63	333.33	327.73
Copper sulphate at 0.2%	16.73	1.48	11.31	28.93	22.67	15.70	351.37	345.20
Copper sulphate at 0.4%	17.10	1.72	9.94	28.63	22.23	16.00	353.77	348.77
Manganese sulphate at 0.2%	17.37	1.63	10.66	26.20	23.63	17.23	350.60	344.60
Manganese sulphate at 0.4%	17.50	1.65	10.61	27.23	24.87	17.50	347.33	343.43
LSD 5%	0.27	0.01	0.21	1.20	0.23	0.41	0.58	0.41
season 2019								
Control	13.57	2.37	5.74	25.32	19.53	16.49	359.53	357.20
Boric acid at 0.5%	14.50	2.09	6.94	28.84	23.57	19.22	348.57	340.90
Boric acid at 1%	15.43	2.00	7.69	31.54	25.53	20.34	344.77	337.43
Calcium chloride at 2%	16.00	1.90	8.42	33.96	28.95	21.45	337.87	331.20
Calcium chloride at 4%	16.43	1.68	9.77	35.31	32.49	24.04	333.77	327.43
Zinc sulphate at 0.2%	17.53	1.64	10.68	37.68	30.44	25.29	339.60	333.93
Zinc sulphate at 0.4%	18.10	1.58	11.53	39.58	34.58	28.38	329.67	324.00
Copper sulphate at 0.2%	15.47	1.83	8.48	29.33	27.57	17.58	348.03	341.70
Copper sulphate at 0.4%	15.93	2.00	7.96	30.29	28.05	18.37	351.10	344.43
Manganese sulphate at 0.2%	14.87	2.16	6.89	28.45	30.63	21.54	346.93	340.93
Manganese sulphate at 0.4%	15.57	2.18	7.17	30.77	31.87	22.42	344.33	339.67
LSD 5%	0.27	0.09	0.42	1.11	0.57	0.21	0.92	0.83

تأثير بعض العناصر الغذائية على نمو ومحصول وجودة ثمار الرمان صنف وندرفل

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الملخص العربي

ان التشقق و لفحة الشمس وانخفاض اللون فى الثمار من أهم المشاكل التى تواجه زراعة الرمان صنف وندرفل. كما أن لها دورا هاما فى تحديد جودة الثمار . أجريت هذه الدراسة خلال موسميين متتاليين هما 2018 و2019 علي أشجار رمان مثمرة بعمر 10 سنوات نامية في بستان خاص بالأراضي حديثة الاستصلاح بمنطقة البستان بمحافظة البحيرة مصر. تمت دراسة تأثير كلا من البورون والكالسيوم والزنك و النحاس والمنجنيز كمعاملات رش ورقي في مرحلة تمام التزهير وبعد ستة أسابيع من تمام التزهير علي أشجار الرمان صنف وندرفل. أوضحت النتائج أن أعلي القيم للنمو الخضري كانت عند رش كلوريد الكالسيوم بتركيز 4% وسلفات الزنك بتركيز 0.4% مقارنة بباقي المعاملات. ووجد أن الرش بكلوريد الكالسيوم 4% وسلفات الزنك 0.4% قلل النسبة المئوية لكل من التساقط و التشقق و لفحة الشمس ، وإلي زيادة المحصول والصفات الطبيعية للثمار مثل وزن الثمار (جم) وحجم الثمار (سم^3) والصلابة وذلك مقارنة بباقي المعاملات كما أدت المعاملات إلي زيادة معنوية في محتوي الصفات الكيماوية للثمرة مثل نسبة المواد الصلبة الذائبة الكلية وكذلك محتوي الثمرة من فيتامين ج . كما أدت المعاملات إلي تحسين اللون في الثمار مقارنة بباقى المعاملات. وعليه يمكن التوصية برش أشجار الرمان صنف وندرفل المثمرة بكلوريد الكالسيوم بتركيز 4% والزنك بتركيز 0.4% في مرحلة تمام التزهير وبعد ستة أسابيع من تمام التزهير، حيث تقلل من النسبة المئوية للتشقق ، ولفحة الشمس و تنتج محصولاً مرتفعاً يتميز بجودة عالية وذلك تحت ظروف التجربة بمنطقة البستان بمحافظة البحيرة.

الكلمات الاسترشادية: الرمان ، لفحة الشمس ، التلوين ، الأنثوسيانين ، العناصر الغذائية ، التشقق