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EFFECT OF MANGANESE AND CALCIUM FOLIAR APPLICATION ON TREE GROWTH, YIELD AND FRUIT QUALITY OF SALEMY POMEGRANATE CULTIVAR

Waleed A.A. Al-Rawi, N.A. Jassim and M.E.A. Al-Hadethi*

Hort. Dept., College Agric., Baghdad Univ., Iraq

ABSTRACT

This study was conducted on 12-years-old Salemy pomegranate trees grown in the pomegranate orchard, Horticultural Station, Al Mahaweel, Babylon province, Iraq, during 2010 and 2011 growing seasons to investigate the influence of manganese and calcium foliar spray on growth, yield and fruit quality of "Salemy" pomegranate cultivar. This work included two factors: manganese (Mn) and calcium (Ca) at various concentrations which were sprayed at the last week of May and first week of June in both seasons. The first factor (Mn) was sprayed at four levels: 0 (Mn_0), 20 (Mn_{20}), 40(Mn_{40}) and 60 (Mn_{60}) mg/l while the other factor (Ca) was added at three levels: 0 (Ca_0), 50 (Ca_{50}), 100(Ca_{100}) mg/l. The obtained results showed that manganese at 60 mg/l and calcium at 100 mg/l (Mn_{60} Ca_{100}) significantly gave the highest leaf area (5.55 and 5.71 cm^2), chlorophyll content (56.39 and 56.36 SPAD unit), fruit set (49.39 and 50.59%) and fruit weight (188.82 and 187.92 g). The lowest value of these parameters were recorded for control (Mn_0 Ca_0) treatment. Beside, these treatments (Mn_{60} Ca_{100}) gained the lowest percentage of fruit splitting (15.62 and 15.55%) in both seasons respectively. Finally, it could be recommend to use such treatments annually for evaluating the effect of spraying these elements at different dates on various pomegranate cultuvars.

Key words: Manganese, calcium, growth, yield, fruit quality, pomegranate.

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 to Iran and is extensively cultivated in the Mediterranean region since ages (Sheikh and Manjula, 2009). The fact that pomegranate fruit has different industrial usage fields such as fruit juice, conserve, vinegar, citric acid and medicine, lead to its gaining popularity in the world market (Aviram and Dornfeld, 2001). The fruit peel, tree stem and root bark and leaves are good source of secondary metabolites such as tannins, dyes and alkaloids (Mirdehghan and Rahemi, 2007). Many factors, including climate, soil, irrigation, variety pruning, insects, and tree nutrition influence the growth and production of fruit trees. Deficiencies of various micronutrients are related to soil types, plants and even to various cultivars. Most micronutrients are readily fixed in soil having alkaline pH. Plant roots are unable to absorb these nutrients adequately from the dry topsoil (Foth and Ellis, 1996). Therefore, fertilization is particularly useful under these conditions where the absorption of nutrients through the soil is difficult, especially with micro-nutrients such as manganese, zinc and iron, Since the micro-mineral elements needed by plants in small amounts it may be added through spraying at the right time to correct and meet the needs of the plant (Kuepper, 2003).

Calcium provides cell wall rigidity by cross-linking of pectic chains of the middle lamella. Disintegration of cell walls and the collapse of the affected tissues are typical symptom of

* **Corresponding author: Tel.** : 009647901239521
E-mail address: mukhtarmustafa@Yahoo.com

calcium deficiency. The proportion of calcium pectate in cell walls is very important for fruit ripening. The increase of fruit calcium content leads to the increase fruit firmness and delays fruit ripening or prevents calcium-related disorders. Moreover, the role of Ca preventing in 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) could result in controlling fruit splitting percentage. Manganese is a heavy metal micronutrient, the functions of which are fairly known. It is involved in the oxygen-evolving step of photosynthesis and membrane function, as well as serving as an important activator of numerous enzymes in the cell (Wiedenhoeft, 2006). Soil application of Mn is problematic, since its efficiency depends on many soil factors, including soil pH. A suitable method for the correction and /or prevention of Mn deficiency in plants is the foliar application of ionic or chelated solution forms of this nutrient (Papadakis *et al.*, 2007).

Many previous studies revealed that foliar spray of calcium and manganese affects some growth and yield characteristics of sprayed Florida Prince and Desert Red peach trees once, twice and thrice/ year with combinations of chelate at the rate of 0.7g/l Fe, 0.3 g/l Zn and 0.3 g/l Mn and found that treatment improved chlorophyll a, b content and increased yield, fruit weight, fruit size and fruit firmness. Hasani *et al.* (2012) found that "Malase Torshe Saveh" pomegranate trees sprayed with Zn and Mn led to increase fruit set, yield as weight or number of fruits/tree and leaf area as well as, fruit characteristics (TSS%, Flesh thickness, weight of 100 arils). Obaid *et al.* (2013) mentioned that the treatment of Salemy pomegranate trees with microelements (Zn and Mn) increased leaf area, leaf dry weight, chlorophyll content, fruit weight and yield. Ahmed *et al.* (2014) found that spraying Manfalouty pomegranate trees with calcium chloride at 2% was very effective in checking fruit splitting and improving yield as well as physical and chemical fruit characteristics.

The objective of this study was to evaluate the effect of spraying calcium and manganese on controlling fruit splitting and improving growth, yield and fruit quality of Salemy pomegranate trees.

MATERIALS AND METHODS

This study was conducted in the pomegranate orchard, Horticultural Station, Al Mahaweel in Babylon province during 2010/2011 growing seasons to investigate the influence of manganese and calcium foliar spray on 12-years-old trees of "Salemy" pomegranate cultivar. Trees were cultivated at 4 × 4 m apart under basin irrigation system. The experimental trees were healthy, similar in vigor and subjected to the same horticultural practices adapted in the region.

Trees were sprayed with four levels of manganese sulphate (0, 20, 40 and 60 mg/l) and three levels of calcium chloride (27.2% Ca), (0, 50 and 100 mg/l). The interaction between these two factors was also studied. Each treatments was replicated three times at a factorial experiment in a completely randomized block design. Each replicate consisted of one tree. All treatments were carried out on the last week of May and first week of June in both seasons. Two main branches from two directions (east and west) of each tree were chosen and tagged on March of the two experimental seasons. The number of flowers was recorded, then set fruits on the selected branches were counted for calculation the percentage of fruit set (number of fruits per branch/total number of flowers per branch × 100). At the harvest time, the fruit weight and the number of splitted fruits were recorded. Then, total yield and the percentage of splitted fruits were calculated. Ten normal fruits were taken from each tree for quality determination. Fruit juice was extracted and the total soluble solids percentage was estimated by hand refractometer. Total acidity in fruit juice (expressed as citric acid/100ml juice according to AOAC (1975) was calculated. Ten leaves from the middle position of the emmarged shoots were randomly taken for measuring leaf area (cm^2), by leaf area meter (Model Cl-202 USA made). Chlorophyll in the leaves was estimated on October by a SPAD meter (Felix Loh and Nina, 2000). The percentage of dry matter in leaves was also calculated.

The obtained results were subjected to analysis of variance according to Elsahookie and Wuhaib (1990) using LSD for comparing differences between various treatment means.

RESULTS AND DISCUSSION

Effect of Calcium and Manganese on Leaf Area, Chlorophyll Content and Leaf Dry Weight

The obtained results of both seasons (Table 1) reveal that spraying pomegranate trees with Ca rates resulted in significant increase in leaf area, chlorophyll content and leaf dry weight. Increasing Ca rate particularly to 100 mg $.Ca.l^{-1}$ gained the highest values of the tested leaf parameters compared to untreated control. Pomegranate trees treated with 60 mg $Mn.l^{-1}$ significantly increased leaf area and chlorophyll content. Results indicated that the combination between manganese and calcium rates displayed that application of 60 mg $Mn.l^{-1}$ and 100 mg $Ca.l^{-1}$ appeared to be the most potent treatment, as it gave the highest leaf area and chlorophyll content (5.55 and 5.71 cm^2, 56.39 and 56.36 SPAD unit for both seasons, respectively). These results are owing to the use of macro and micronutrients which play an important role in the representation of critical auxins that increase cell division and increase chlorophyll content in the leaf, which works to increase leaf area. These results are in agreement with those obtained by Asaad (2014) on apple trees and Ahmed *et al.* (2014) on pomegranate trees, they found that the leaf area and chlorophyll content were positively correlated with Mn and Ca spray in those trees.

Effect of Calcium and Manganese on Fruit Set, Fruit Weight and Yield

Data concerning the effect of the tested treatments on fruit set percentage, fruit weight (g) and yield (kg) during the two experimental seasons are listed in Table 2. The data clear that, calcium and manganese foliar spray increased significantly fruit set percentage compared with the control at both seasons. Moreover, spraying calcium at 100 $mg.l^{-1}$ combined with manganese at 60 $mg.l^{-1}$ was more effective than the other treatments, since it gave the highest fruit set percentage (49.39 and 50.59%) in both seasons, respectively. This result may be due to the use of manganese and calcium is needed in relatively very small quantities for adequate plant growth and fruit production. Results as shown in Table 2 indicate that, control treatment was the highest in the fruit weight. Perhaps due to the role of these elements in increasing the number of perfect flowers and increase fruit set, leading to increase number of fruits and consequently increased food competition and then reduce fruit weight (Jomaa, 2008).

Results shown in Table 2 indicate that, spraying calcium and manganese exhibited favorable effect on increasing yield in the two experimental seasons. The highest yield was recorded by spraying calcium at 100 $mg.l^{-1}$ combined with manganese at 60 $mg.l^{-1}$.

In general, these results are in line with those obtained by Świątkiewicz and Błaszczyk (2009) on apple trees, and El-Shazly *et al.* (2013) on peach trees. They reported that foliar spray of calcium increased fruit set, fruit weight, and consequently increased the yield. Also, Hassan *et al.* (2010) found that foliar spray of chelated mixture (Zn, Mn, and Fe) increased the fruit set and total yield of Florida Prince and Desert Red peach trees and Hollywood plum trees, respectively.

Effect of Calcium and Manganese on Splitting Fruit, Total Soluble Solids (TSS) and Total Acidity (TA)

Data in Table 3 show that foliar application with calcium reduced the percentage of splitting fruits in Salemy pomegranate cultivar in both seasons. The minimum splitting percentages were observed on trees treated with the highest concentration of calcium (100 $mg.l^{-1}$). The previous positive action of calcium on reducing fruit splitting of Salemy pomegranate trees might be attributed to the important roles of Ca 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 (Tony and John, 1994; Jackman and Stanley, 1995). In our experiment each of Mn and Ca sprays had significant positive effects on TSS, but the effect of Ca was more reasonable than Mn in increasing TSS, although their combination resulted in relatively higher TSS (Table 3). The increase in total soluble solids percentage after spraying with Ca and Mn may be due to the role of these elements in

Table 1. Effect of Ca and Mn foliar spray on leaf area, chlorophyll content and leaf dry weight of "Salemy" pomegranate trees (2010 and 2011 seasons)

Treatments		Leaf area (cm^2)		Chlorophyll content (SPAD)		Leaf dry weight (mg)	
Ca*	Mn**	2010	2011	2010	2011	2010	2011
0	0	4.64	4.62	51.59	52.29	45.33	45.39
	20	4.69	4.69	51.91	52.36	45.38	45.42
	40	4.69	4.78	52.24	52.47	45.44	45.49
	60	4.89	4.95	52.49	52.74	45.50	45.55
50	0	4.68	4.73	52.19	52.42	45.80	45.91
	20	4.88	4.99	52.68	52.96	45.84	45.98
	40	4.98	5.26	53.39	53.24	45.93	46.13
	60	5.22	5.37	53.52	53.99	46.18	46.30
100	0	4.87	5.06	53.42	53.13	45.92	46.14
	20	5.16	5.28	53.83	54.54	46.18	46.30
	40	5.39	5.50	55.00	55.73	46.31	46.41
	60	5.55	5.71	56.39	56.36	46.43	46.60
LSD 5%	Ca	0.25	0.27	1.11	1.20	0.38	0.41
	Mn	0.29	0.32	1.28	1.39	NS	NS
	Interaction	0.50	0.54	2.22	2.40	0.78	0.82

Mn** : As manganese sulphate (mg l^{-1}) Ca* : As calcium chloride (mg l^{-1})

Table 2. Effect of Ca and Mn foliar spray on fruit set percentage, fruit weight (g) and yield (kg) of "Salemy" pomegranate trees (2010 and 2011 seasons)

Treatments		Fruit set (%)		Fruit weight (g)		Yield (Kg)	
Ca*	Mn**	2010	2011	2010	2011	2010	2011
0	0	41.26	43.27	200.10	200.31	23.25	23.56
	20	42.47	45.21	198.54	197.42	23.56	23.65
	40	44.03	45.49	195.75	195.64	23.71	23.81
	60	45.42	46.10	194.09	193.11	23.87	23.95
50	0	43.60	43.90	196.62	195.90	24.69	24.59
	20	45.27	45.92	194.30	193.63	24.99	24.97
	40	46.82	47.14	193.00	192.45	25.17	25.07
	60	48.10	48.83	191.19	191.00	25.49	25.40
100	0	45.72	46.38	193.27	192.12	25.88	25.74
	20	46.93	48.04	192.18	190.95	26.05	25.97
	40	47.96	49.49	190.24	189.29	26.49	26.56
	60	49.39	50.59	188.82	187.92	26.87	26.79
LSD 5%	Ca	1.34	1.47	1.55	1.62	1.17	1.20
	Mn	1.55	1.70	1.79	1.87	N.S	N.S
	Interaction	2.68	2.94	3.10	3.24	2.34	2.40

Mn** : As manganese sulphate (mg l^{-1}) Ca* : As calcium chloride (mg l^{-1})

Table 3. Effect of Ca and Mn foliar spray on splitting fruit percentage, total soluble solids (TSS%) and total acidity (TA%) of "Salemy" pomegranate fruits (2010 and 2011 seasons)

Treatments		Splitting fruit (%)		TSS (%)		TA (%)	
Ca*	Mn**	2010	2011	2010	2011	2010	2011
0	0	22.65	22.13	11.78	11.67	1.55	1.58
	20	22.54	22.11	11.97	11.88	1.53	1.56
	40	22.32	21.97	12.09	12.00	1.47	1.52
	60	22.10	21.85	12.34	12.22	1.41	1.46
50	0	19.08	18.22	12.11	12.04	1.48	1.50
	20	18.74	18.08	12.44	12.41	1.48	1.47
	40	18.50	17.83	12.75	12.66	1.43	1.42
	60	18.38	17.77	12.99	12.91	1.39	1.40
100	0	16.12	15.94	12.86	12.80	1.44	1.45
	20	15.96	15.77	13.17	13.11	1.42	1.44
	40	15.78	15.72	13.56	13.43	1.38	1.40
	60	15.62	15.55	13.81	13.77	1.37	1.38
LSD 5%	Ca	1.39	1.52	0.44	0.50	NS	NS
	Mn	NS	NS	0.51	0.58	NS	NS
	Interaction	2.78	3.04	0.88	1.00	NS	NS

Mn** : As manganese sulphate (mg l^{-1}) Ca* : As calcium chloride (mg l^{-1})

increasing vegetative growth activities (Table 1) which led to absorb more nutrients (Al-Rawi *et al.*, 2012). Moreover, they had a role in the efficiency of photosynthesis process, thereby increasing manufactured materials in the leaves which move to the fruit and increases their components and properties. Values in Table 3 show that total acidity was insignificantly affected by calcium and manganese spray.

These results are in line with those obtained by Khalil and Aly (2013) and Ahmed *et al.* (2014) .They reported that foliar spray of Ca increased TSS and reduced cracking of the pomegranate fruits. Also, Al-Hawezi (2008) found that foliar spray of Mn increased TSS percentage in grape berries. It has been reported that foliar application of zinc combined with manganese markedly increased TSS percentage and insignificantly affected total acidity percentage (Hasani *et al.*, 2012).

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تأثير الرش بالمنجنيز والكالسيوم على نمو وحاصل وجودة ثمار صنف الرمان سليمي

وليد عبد الغني أحمد الراوي - نجم عبود جاسم - مصطفى عيادة عداي الحديثي

قسم البستنة - كلية الزراعة - جامعة بغداد - العراق

أجريت هذه التجربة على أشجار الرمان صنف سليمي عمر ١٢ سنة والمنزرعة في بستان رمان تابع لمحطة البستنة في ناحية المحاويل بمحافظة بابل خلال موسمي ٢٠١٠ و٢٠١١ لدراسة تأثير رش المنجنيز والكالسيوم بمعدلات مختلفة على نمو ومحصول وجودة ثمار الرمان صنف سليمي، حيث استخدم في هذه التجربة عاملان هما: رش المنجنيز (Mn) والكالسيوم (Ca) في الأسبوع الأخير من أيار والأسبوع الأول من حزيران لكلا الموسمين، العامل الأول هو أربع مستويات من المنجنيز هي [صفر (Mn_0)، ٢٠ (Mn_{20})، ٤٠ (Mn_{40}) و٦٠ (Mn_{60}) ملجم/لتر] وثلاث مستويات من الكالسيوم [صفر (Ca_0)، ٥٠ (Ca_{50}) و١٠٠ (Ca_{100}) ملجم/لتر]، وأظهرت النتائج أن رش الأشجار بالمنجنيز بتركيز ٦٠ ملجم/لتر والكالسيوم بتركيز ١٠٠ ملجم/لتر ($Mn_{60}Ca_{100}$) قد تفوقت على باقي المعاملات في مساحة الورقة حيث أعطت أعلى مساحة للورقة (٥,٥٥ و ٥,٧١ سم^2)، وأعلى محتوى للأوراق من الكلوروفيل (٥٦,٣٩ و٥٦,٣٦ وحدة SPAD)، وأعلى نسبة لعقد الثمار (٤٩,٣٩ و ٥٠,٥٩%)، وأكبر وزن للثمرة الواحدة (١٨٨,٨٢ و١٨٧,٩٢جم)، كما كانت أقل القيم لهذه القياسات في معاملة المقارنة (Mn_0Ca_0)، كما حققت المعاملة $Mn_{60}Ca_{100}$ أقل نسبة لتشقق الثمار (١٥,٦٢ و١٥,٥٥%) خلال موسمي الدراسة، على التوالي، ويمكن أن نوصي بإجراء هذه المعاملات سنوياً لدراسة تأثير هذه العناصر في مواعيد أخرى وعلى أصناف أخرى من الرمان.

المحكمـــــون:

١- أ.د. طلعت على محمد سيد أحمد أستاذ الفاكهة – كلية الزراعة – جامعة الزقازيق.

٢- أ.د. صفـاء عبـدالغنـــي أحمـد أستاذ الفاكهة – كلية الزراعة – جامعة الزقازيق.