CATRINA (2007), 2 (1): 45 -49

Improving Washington Navel Orange Trees Productivity by Foliar Spray with Calcium Chloride, Calcium Nitrate and Calcium Chelate

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ABSTRACT

Nine years old Washington Navel Orange Trees grow on clayey soil at Ashmoun District, AlMenoufya Governorate, Egypt; were sprayed with calcium chloride at 1, 2 and 3%, calcium nitrate at 1, 2 and 3% and calcium chelate at 1000, 2000 and 3000ppm at 3 spraying dates; 15th of April, 15th of June and 15th of August. Results indicated that spraying nutrients increased N, P, K and Ca content in leaves compared with the untreated trees. Meanwhile, yield as number of fruits and number of fruits/tree were significantly improved by spraying different nutrient especially when sprayed with calcium nitrate or calcium chloride at 3%. Creasing and fruit cracking/trees were significantly decreased by spraying calcium chloride at 3%. However fruit quality (physical and chemical characteristics) were significantly improved by spraying different nutrient treatments at higher concentrations.

Keywords: Washington Navel Orange, foliar spray, Mineral content, Yield and Fruit quality, Creasing, Fruit cracking.

INTRODUCTION

Citrus plants are the most important world fruit crops. Washington Navel Orange is considered as the most popular citrus fruits in Egyptian market. Trees may have the problem of low productivity due to suffering from deficiencies in some macro and micro nutrients. Spraying Washington Navel Orange Trees with Potassium, Phosphorus, Calcium and Boron as macro and micro nutrients have a positive effect on leaf mineral content, fruit set, yield and fruit quality (Abd-Allah, 2006).

Calcium prevents the increase in the apparent free space of tissues usually associated with senescence and maintains the protein synthesizing ability of the cells. So, Ca appears to protect fruit cell membranes from disorganization which delays but doesn't prevent senescence (Faust, 1975). It plays a special role in maintaining the cell wall structure in fruits and other storage organs by interacting with the pectic acid in the cell walls to form calcium pectate (Poovaiah, 1986). Also it maintains the membrane function and this effect is due to a consequence of calcium binding to the outer surface of the plasma membrane where calcium can affect membrane fluidity (Ferguson and Drobat, 1988).

Calcium promotes early root formation and growth, improves general plant vigor and stiffness of stalks and improves fruit integrity. It influences the uptake of other nutrients such as Phosphorous, Manganese, Iron, Zinc and Boron (Polevoiy, 1989).

The aim of the present work was to study the effect of different Calcium spraying on leaf mineral content, yield and fruit quality of washington Navel orarge Trees.

MATERIALS AND METHODS

This study was carried out at Ashmoun District, AlMenoufya Governorate during the seasons of 2004 and 2005. Healthy and nearly uniform Washington Navel Orange Trees of 9 years old budded on sour orange rootstock (*Citrus aurantium* L.) grown in clayey soil. The trees were planted at five meters apart and were irrigated with closed basin surface system. All the plants had received the normal horticultural practices. Other than the control (sprayed with water only), the trees were sprayed with one of the following solutions:

1- Calcium Chloride at 1.0%
2- Calcium Chloride at 2.0%
3- Calcium Chloride at 3.0%
4- Calcium Nitrate at 1.0%
5- Calcium Nitrate at 2.0%
6- Calcium Nitrate at 3.0%
7- Calcium Chelate at 1000 ppm
8- Calcium Chelate at 2000 ppm
9- Calcium Chelate at 3000 ppm

In this respect, all treatments were sprayed three times; on 15th of April, 15th of June and 15th of August in both seasons. The other cultural practices were the same for all tress. Each treatment was replicated three times on one tree plot and the randomized complete block design was followed.

Measurements and Determinations

1- Leaf Samples

To determine leaf mineral content, forty leaves were taken in late August in each season from tagged non-fruiting and non-flushing spring growth cycle (Jones and Embleton, 1960). Leaf samples were washed with tap water then with distilled water, dried at 70°C finally ground and digested. The digested solution was used to determine N, P, K, and Ca content as percentage on dry weight bases using the methods described by Cottenie *et al*. (1982).

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2- Yield

The fruits were harvested when reached maturity according to Schirra *et al.* (1997), then number of fruits per tree were counted and weighed in Kg.

3- Fruit Quality

At maturity stage, a representative sample of 10 fruits was taken from each tree (replicate) and the following characteristics were determined:

(a) Physical Characteristics

Average fruit weight (g), fruit volume (cm^3), fruit peel thickness (cm), and fruit firmness (by means of Magness Taglor Pressure Tester) were measured. The fruit length and diameter (cm) were measured by a vernier calliper and the fruit shape index (length/diameter ratio) was calculated. Meanwhile, Yield and percentage of fruit cracking (number of cracking fruits/total number of fruits) and percentage of fruit creasing (number of creasing fruits /total number of fruits) were determined.

(b) Chemical Characteristics

Juice weight, total soluble solids percentage, titratable acidity content and ascorbic acid content (mgm/100 ml juice) were determined according to the standard procedures (A.O.A.C., 1990). The total soluble solids (TSS)/acid ratio for each sample was calculated.

RESULTS

Leaf Nutrient Contents

Table (1) shows that the highest N percentage in both seasons was recorded with Calcium Nitrate (3%, 2% respectively), followed by Calcium Chloride (2%) in the first season. On the other hand, no appreciable differences were noticed among different treatments under study in both seasons regarding leaf Phosphorous and Potassium contents.

Also, all treatments under investigation maximized leaf calcium content as compared with the control in both seasons. In this respect, the highest Ca% was recorded with Calcium Nitrate (1%) in the first season and Calcium Chloride (3%), Calcium Nitrate (3%) and Calcium Chelate (3000 ppm) in the second season.

Yield and Physical Characteristics

It is clear from table (2) that spraying with Calcium Chloride at the rate of (3%) resulted in significant decrease in fruit creasing followed by Calcium Chelate (3000 ppm). However, growth parameters (yield and number of total fruit/tree) of Washington Navel Orange trees were significantly promoted by foliar application of Calcium Chloride (2 and 3%) as well as Calcium Nitrate (3%) in both seasons. Meanwhile, percentage fruit cracking/trees was decreased as foliar application of Calcium Chloride (3%) and Calcium Chelate (3000 ppm).

Data in table (3) discloses that fruit weight and fruit size were increased as highest concentrations of Calcium treatments were used as compared with lower concentrations and the control in both seasons. However peel thickness was significantly affected by spraying Calcium Nitrate (1 and 3%) treatment alone; followed by Calcium Chloride (2 and 3%). Calcium Nitrate (3%) gave the highest values in the first season. While in the second season, both Calcium Chloride and Calcium Nitrate at higher concentration (3%) treatment; followed by Calcium Nitrate at (1 and 2%) recorded the higher thickness of peel. Meanwhile, both Calcium Chelate (3000 ppm) and Calcium Chloride (2 and 3%) treatments resulted in significant increase in fruit firmness; followed by Calcium Nitrate (2 and 3%) as well as Calcium Chelate (2000 ppm) in the first season. The results of the second season took the same trend of the first one.

Table (4) indicates those fruit height and fruit diameters were significantly increased in the second season only. On the other hand, no significant difference was obtained between all treatment and the control were used when fruit height and fruit diameter were concerned in the first season and fruit shape index in both seasons.

Table (1): Effect of Calcium Chloride, Calcium Nitrate and Calcium Chelate sprays on some leaf mineral content of Washington Navel Orange Trees.

Nutrients	N (%)		P (%)		K (%)		Ca (%)	
Season / Treatment	2004	2005	2004	2005	2004	2005	2004	2005
Control (untreated)	2.28	2.36	0.22	0.24	1.59	1.61	3.87	3.73
Calcium chloride 1%	2.36	2.40	0.23	0.24	1.62	1.61	3.98	3.89
Calcium chloride 2%	2.52	2.38	0.23	0.23	1.65	1.65	4.11	3.98
Calcium chloride 3%	2.41	2.43	0.23	0.23	1.58	1.67	4.14	4.10
Calcium nitrate 1%	2.36	2.42	0.23	0.24	1.60	1.64	4.91	4.00
Calcium nitrate 2%	2.39	2.50	0.23	0.24	1.63	1.65	4.01	4.08
Calcium nitrate 3%	2.69	2.56	0.23	0.24	1.65	1.66	4.09	4.13
Calcium chelate 1000 ppm	2.14	2.35	0.22	0.24	1.57	1.60	4.00	3.86
Calcium chelate 2000 ppm	2.36	2.39	0.23	0.24	1.60	1.63	4.08	4.05
Calcium chelate 3000 ppm	2.29	2.41	0.23	0.24	1.60	1.65	4.13	4.12
L.S.D. at 0.05	0.11	0.09	NS	NS	NS	NS	0.09	0.12

Table (2): Effect of calcium chloride, calcium nitrate and calcium chelate sprays on creasing, yield, number of total fruit and fruit cracking percentage of Washington Navel orange trees.

Characteristics	Fruit creasing/ tree (%)		Yield/tree(Kg)		Number of total fruit/tree (number)		Fruit cracking/ tree (%)	
Season / Treatment	2004	2005	2004	2005	2004	2005	2004	2005
Control (untreated)	1.00	1.00	31.95	36.95	206.00	229.00	9.00	8.00
Calcium chloride 1%	0.90	1.00	40.20	47.54	223.00	258.00	8.00	6.00
Calcium chloride 2%	0.70	0.80	45.28	52.08	246.00	276.00	5.00	4.00
Calcium chloride 3%	0.40	0.50	49.11	56.74	257.00	291.00	1.00	2.00
Calcium nitrate 1%	0.90	0.90	43.11	42.19	238.00	234.00	9.00	7.00
Calcium nitrate 2%	0.80	0.80	44.77	48.85	250.00	264.00	6.00	6.00
Calcium nitrate 3%	0.70	0.80	49.30	55.09	260.00	289.00	4.00	3.00
Calcium chelate 1000 ppm	0.80	0.90	35.98	42.29	219.00	247.00	9.00	7.00
Calcium chelate 2000 ppm	0.70	0.80	39.37	45.99	234.00	260.00	6.00	5.00
Calcium chelate 3000 ppm	0.50	0.70	42.29	50.92	247.00	263.00	2.00	3.00
L.S.D. at 0.05	0.01	0.02	5.27	5.69	14.12	13.91	1.46	1.12

Table (3): Effect of calcium chloride, calcium nitrate and calcium chelate sprays on fruit weight, fruit size, fruit peel thickness and firmness of Washington Navel orange trees.

Characteristics	Fruit weight (g)		Fruit size (cm)		Peel thickness (cm)		Fruit firmness (Kg/cm^3)	
Season / Treatment	2004	2005	2004	2005	2004	2005	2004	2005
Control (untreated)	155.12	161.36	184.33	182.09	0.41	0.38	14.10	13.83
Calcium chloride 1%	180.23	184.27	199.13	212.30	0.47	0.46	17.52	18.10
Calcium chloride 2%	184.05	189.16	207.00	214.01	0.49	0.47	22.66	22.65
Calcium chloride 3%	191.10	195.02	212.30	236.00	0.49	0.50	23.20	23.10
Calcium nitrate 1%	181.23	180.29	205.36	203.03	0.51	0.49	16.32	17.15
Calcium nitrate 2%	174.09	185.03	210.83	216.43	0.49	0.49	18.10	19.10
Calcium nitrate 3%	189.61	196.76	217.06	202.13	0.53	0.52	19.70	19.62
Calcium chelate 1000 ppm	164.32	172.03	190.00	199.18	0.45	0.45	17.10	16.40
Calcium chelate 2000 ppm	168.24	176.90	197.29	207.28	0.46	0.45	19.85	20.10
Calcium chelate 3000 ppm	171.23	179.93	194.30	210.60	0.48	0.46	22.23	21.03
L.S.D. at 0.05	18.26	16.38	21.27	18.73	0.03	0.04	2.27	1.32

Chemical Properties

It is clear from table (5) that in both seasons, spraying Calcium Nitrate at (2 and 3%) increased T.S.S. content significantly as compared with the other used treatments and the control. On the other hand, no significant increase was found in juice volume percentage. As for the acidity percentage, fruit juice was significantly increased by spraying all Calcium treatments at higher concentrations in both seasons. However, all calcium treatments significantly decreased TSS/acid ratio as compared with the control. The lowest Calcium Nitrate concentrations (1%) gave the best results for TSS/acid ratio of both seasons. Meanwhile, the highest Calcium Chloride concentrations (3%) gave the best results for the V.C. content in the first season. Also, the highest Calcium Nitrate concentrations (3%) gave the best ones in the second season. Conclusively, juice volume total soluble solids, TSS/acid ratio and Ascorbic acid content generally increased as spraying calcium Chloride (3%) treatment. On the other hand, the effect of treatment on total soluble solids and acidity content were not significant.

DISCUSSION

Our results on the effect of foliar spraying with Calcium Chloride, Calcium nitrate and Calcium Chelate on leaf nutrient content somehow go in line with the findings of Harty *et al.* (2004) on Navel Orange. They reported that sprayed Calcium Chloride and Calcium Nitrate treatments increased Calcium levels in leaf. Meanwhile, Abd-Allah (2006) concluded that spraying Washington Navel Orange Trees with Potassium, Phosphorous, Calcium and Boron as macro or micro nutrients have a positive effect on leaf mineral content. Results also indicated that spraying Washington Navel Orange trees with Calcium Chloride (3%) or Calcium Nitrate increased yield and number of total fruit/trees. These results are in agreement with Monselise and Costo (1985) and Garcia-Kuis *et al*. (1994). They found that the application of Calcium Nitrate sprays at the beginning of cell enlargement stage significantly reduces the proportion of fruit affected by splitting of orange fruits. Results of effect of calcium chloride, calcium nitrate and calcium chelate sprays on fruit weight, fruit size, fruit peel thickness and firmness are in agreement with the findings of Poovaiah (1986), Ferguson and Drobat (1988) and Almela *et al.* (1994). These scientists pointed out that Calcium has an important role in maintaining the cell wall structure and membrane integrity by the interaction of Calcium with pectic acid in cell wall to form Calcium pectate. Moreover, they added that Calcium causes a reduction or delay in cell wall breakdown, and this effect causes a delay in fruit softening of citrus fruit trees.

Table (4): Effect of Calcium Chloride, Calcium Nitrate and Calcium Chelate sprays on fruit height, fruit diameter and fruit shape index of Washington Navel Orange Trees.

Characteristics	Fruit Height (cm)		Fruit Diameter (cm)		Fruit Shape Index	
Season / Treatment	2004	2005	2004	2005	2004	2005
Control (untreated)	7.30	7.52	7.29	7.29	1.00	1.30
Calcium chloride 1%	7.83	7.86	7.70	7.52	1.02	1.05
Calcium chloride 2%	7.82	7.88	7.70	7.50	1.02	1.05
Calcium chloride 3%	7.85	7.92	7.57	7.61	1.04	1.04
Calcium nitrate 1%	7.83	7.83	7.60	7.60	1.03	1.03
Calcium nitrate 2%	7.82	7.80	7.66	7.58	1.02	1.03
Calcium nitrate 3%	7.78	7.88	7.51	7.56	1.04	1.04
Calcium chelate 1000ppm	7.39	7.48	7.15	7.26	1.03	1.03
Calcium chelate 2000ppm	7.42	7.59	7.26	7.33	1.02	1.04
Calcium chelate 3000ppm	7.74	7.73	7.53	7.48	1.03	1.03
L.S.D. at 0.05	NS	0.09	NS	0.18	NS	NS

Table (5): Effect of calcium chloride, calcium nitrate and calcium chelate sprays on fruit chemical properties of Washington Navel Orange Trees.

Characteristics	Juice Volume (%)		TSS (%)		Acidity (%)		TSS/Acid ratio		V.C. (mg/100ml juice)	
Season / Treatment	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Control (untreated)	40.20	41.00	12.00	12.70	1.20	1.13	10.00	11.24	38.99	35.29
Calcium chloride 1%	38.31	41.60	11.27	12.01	1.17	1.16	9.63	10.35	38.62	35.93
Calcium chloride 2%	39.83	41.31	11.95	12.31	1.21	1.22	9.88	10.09	40.39	37.20
Calcium chloride 3%	39.99	40.20	12.48	12.98	1.33	1.29	9.38	10.06	41.12	37.90
Calcium nitrate 1%	40.31	39.16	12.21	12.97	1.19	1.13	10.26	11.48	38.80	36.41
Calcium nitrate 2%	39.76	40.19	12.73	13.14	1.26	1.23	10.10	10.68	39.17	37.23
Calcium nitrate 3%	39.81	40.22	13.11	13.63	1.33	1.30	9.86	10.28	40.16	38.11
Calcium chelate 1000ppm	40.62	41.27	11.91	12.80	1.23	1.20	9.68	10.67	38.00	35.92
Calcium chelate 2000ppm	40.11	40.32	11.73	12.30	1.29	1,25	9.09	9.84	38.16	36.17
Calcium chelate 3000ppm	20.62	41.06	11.56	11.83	1.31	1.30	8.82	9.10	38.81	37.09
L.S.D. at 0.05	NS	NS	1.03	0.96	0.11	0.12	0.73	0.81	1.05	1.11

Poovaiah (1986) and El-Shafey *et al.* (2002) reported that Calcium depressed fruit respiration, delayed the onset of climacteric stage and the increased Calcium levels in fruit tissues altered various parameters of senescence such as respiration of Valencia Orange our results on the effect of Calcium Chloride, Calcium Nitrate and Calcium Chelate sprays on fruit height, fruit diameter and fruit shape index agrees with these results.

The present results on the effect of calcium chloride, calcium nitrate and calcium chelate sprays on fruit chemical properties of Washington Navel Orange Trees are in general harmony with El-Hilali *et al.* (2003) and Sandhu (1992). They found that the spraying with Ca (1 and 2%) Calcium Nitrate on Mandarin fruits is shown to be the best juice acid content.

REFERENCES

A.O.A.C. 1990. Official Methods of Analysis. The Association of Official Analytical Chemists. 15th Ed Arlington, West Virginia, USA. Washington D.C.

ABD-ALLAH, A.S.E. 2006. Effect of Spraying some Macro and Micro Nutrients on Fruit Set, Yield and Fruit Quality of Washington Navel Orange Trees. Journal of Applied Sciences Research **2** (11): 1059-1063.

ALMELA, V., S. ZARAGOZ, E. PRIMOMILLO, AND M. AGUSTI. 1994. Hormonal Control of Splitting of Nova Mandarin Fruit. Journal of Horticulture Science **69**: 969- 973.

COTTENIE A, L. VERLOO, G. KIEKENS, AND R CAMERLYNUCK. 1982. Chemical Analysis of Plant and Soil. Laboratory of Analytical and Agrochemistry State University Belgium.

EL-HILALI, F, A. AITOUBAHOU, A.REMAH, AND O. A. KHAYAT. 2003. Chilling Injury and Peroxide Activity Changes in "Fortune" Mandarin Fruit Low Temperature Storage. Journal of Plant Physiology **29**: 44-54.

EL-SHAFEY, Y.H., A.M. ABD EL-RAHMAN, AND A. M. EL AZAZE. 2002. Effect of Foliar Application with Calcium on Yield and Fruit Quality of Valencia Orange. Bullutin of Faculty of Agriculture Cairo University **53**: 275-288.

FAUST. M. 1975**.** The Role of Calcium in the Respiratory Mechanism and Senescence of Apples. Resh Science **238**: 87-92.

FERGUSON, I.B., AND B.K. DROBAT. 1988. Calcium and the regulation of plant growth and senescence. Horticulture Science **23**(2): 262-266.

GARCI-KUIS. A, A.M.M. DURATE, A. GARCIA-LIDAN, AND J.L. GUARDIOLA. 1994. Fruit Splitting in Nova Hybrid Mandarin in Relation to the Anatomy of the Fruit and Fruit Set Treatments. Scientia Horticulture **57** (3): 215-231.

HARTY, A., W. DOOLING, AND A. LITTLE. 2004. Producing World Class Navel Orange in New Zealand – Part 2: Rind Strengthening and Cling Spray Research. Orchardist **77**(5):58-61.

JONES, W.W., AND T.W. EMBLETON. 1960**.** Leaf Analysis Nitrogen Control Programs for Oranges. Calif. Citrogr **45**: 394-353.

MONELISE, S.P., AND J. COSTO. 1985. Decreasing Splitting Incidence in Murcott by 2, 4 D and Calcium Nitrate. Alon Hanotea **39**: 731-733.

POLEVOIY, V.V. 1989. Calcium-related Physiological Disorders of Plant. Annual Review of Phytopathology **17**: 97-122.

POOVAIAH, B.W. 1986. Role of Calcium in Prolonging Storage Life of Fruits and Vegetables. Food Technology **5**: 86-88.

SANDHU, S.S. 1992. Effect of Pre-harvest Sprays of Gibberellic Acid, Vipul, Calcium Chloride and Bavistin on the Tree Storage of Kinnow Fruits. Acta Horticulturae **321**: 366-371.

SCHIRRA, M., M. AGABBIO, D.G. HALLEWIN, M. PALA, AND R. RUGGIU. 1997**.** Response of Tarocco Oranges to Picking Date, Post-harvest, Hot Water Dips and Chilling Storage Temperature. Journal of Agricultural and Food Chemistry **45** (8): 3216-3220.

Received June 19, 2007
Accepted August 25, 2007

تحسين إنتاجية أشجار البرتقال أبو سرة بالرش بكلوريد الكالسيوم، نترات الكالسيوم، والكالسيوم المخلبى

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الملخص العربـــى

أجريت هذه الدراسة خلال موسمى 2004، 2005 على أشجار برتقال أبو سرة عمر 9 سنوات مطعومة على أصل النارنج فى أحد البساتين الخاصة بأشمون بمحافظة المنوفية وذلك لدراسة تأثير الرش بكلوريد الكالسيوم ونترات الكالسيوم بتركيزات 1، 2، 3% وكذلك الرش بالكالسيوم المخلبى بتركيز 1000، 2000، 3000 جزء فى المليون وذلك فى ثلاث مواعيد اضافة مختلفة هى 15 أبريل، 15يونيو و15 أغسطس.

و قد تم دراسة تأثير هذه المعاملات على النسبة المئوية للتبحير، المحصول، الصفات الطبيعية للثمار (وزن الثمرة، حجم الثمرة، صلابة الثمرة، النسبة المئوية للثمار المتشققة)، والصفات الكيماوية للثمار (حجم العصير، المواد الصلبة الذائبة الكلية، الحموضة، نسبة المواد الصلبة الى الحموضة، فيتامين C). كما تم دراسة بعض العناصر فى الأوراق (نيتروجين، فوسفور، كالسيوم، بوتاسيوم).

وقد توصلت الدراسة إلى أن معظم المعاملات أدت إلى زيادة محتوى الورقة من النيتروجين والفوسفور والبوتاسيوم والكالسيوم وزيادة ملحوظة فى عدد الثمار، ووزن الثمار، والمحصول خاصة عند الرش بكلوريد الكالسيوم أو نترات الكالسيوم بتركيز 3%. كما أدى الرش بكلوريد الكالسيوم بتركيز 3% الى تقليل نسبة التبحير وتشقق الثمار. كما أوضحت نتائج البحث أن جميع المعاملات وخاصة التركيزات العالية أدت الى زيادة المواد الصلبة الذائبة والسكريات الذائبة الكلية كما ساعدت على تحسين صفات الجودة للثمار المختبرة.