



EFFECT OF CALCIUM AND BORON SOURCES AND METHODS OF APPLICATION ON GROWTH YIELD AND FRUIT QUALITY OF WASHINGTON NAVEL ORANGE TREES

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ABSTRACT

This study was carried out during 2013 and 2014 seasons to examine the effect of soil addition of Calcium nitrate at 1.0 kg/tree, borax at 25 g/tree and /or spraying of chelated-Ca at 0.03% and chelated-B at 0.025% on growth, yield and fruit quality of Washington Navel orange trees.

Varying sources and methods of application for both Calcium and boron had an announced effect on growth, leaf content of pigments and nutrients, yield and fruit quality. Using both calcium and boron via leaves was superior than using both via soil and using chelated form of both nutrients was favorable than using calcium nitrate or borax for Ca and B, respectively. Using Ca and B via leaves in chelated forms at 0.03 and 0.025% respectively gave the best results comparing with using both together via soil.

A pronounced effect on yield and fruit quality of Washington Navel orange trees was obtained with spraying chelated-Ca at 0.03% plus chelated-B at 0.025 % three times at growth start, just after fruit setting and three weeks later.

INTRODUCTION

Growers of citrus crops especially Washington Navel orange trees did not supply the trees with their adequate requirements of calcium and boron.

Deficiency of Ca and B is followed by lowering the yield and had unfavorable effects on fruit quality (Nijjar, 1985).

Calcium had many important functions for fruit crops. It is responsible for strengthening the plant cells and enhancing cell division and N fixation by microorganisms, root development and uptake of some nutrients. Misformation of flowers and fruits might be attributed to the deficiency of Ca (Nijjar, 1985). Previous studies showed that Ca had beneficial effects on fruiting of fruit crops (Ahmed et al 2001; Yesiloglu and Acikalin, 2002; Abd-Allah, 2006 and Hassan-Huda, 2014)

Boron has many functions in plant nutrition. It has many regulatory important roles in stimulating cell division, nutrient uptake, pollen germination, water uptake as well as biosynthesis and translocation of sugars (Gaugh and Dugger, 1953, Percia et al 2001 and Ahmed et al 2009). The results of Ebeid-Sanaa (2007) on Hindi Bisinnara mangoes, El-Sayed-Esraa (2007 and 2010) on Ewaise mangoes, Mahmoud et al (2007) on Hindi Bisinnara mangoes, Abdalla (2008) and Attala et al (2011) on Zaghloul dates, Gamal (2013) on Washington Navel oranges; Ahmed et al (2013) Zaghloul dates, and Abd-El-Wahab (2015) on Sucary mangoes confirmed the beneficial effects of using boron on fruiting of fruit crops.

The target of this study was elucidating the best sources and methods of calcium and boron application that were responsible for improving yield and fruit quality of Washington Navel orange trees.

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MATERIALS AND METHODS

This study was carried out during 2013 and 2014 seasons on twenty-one uniform and similar in vigour 15-years old Washington Navel orange trees onto sour orange rootstock. The selected trees are grown in a private citrus orchard located at Abo Saleh Island near Bany Suef city, Bany Suef Governorate. The trees are planted at 6x6 meters apart. The texture of the soil is silty clay (**Table 1**) with a water table not less than two meters deep. Surface irrigation system was carried out using Nile water. The selected trees subjected to the normal horticultural practices that already applied in the orchard. Analysis of the soil was done according to **Wilde et al (1985)**.

Table 1. Analysis of the tested soil

Characters	Values
Practical size distribution	
Sand %	7.5
Silt %	61.0
Clay %	31.5
Texture	Silty clay
pH (1 : 2.5 extract)	8.80
E.C. (1 : 2.5 extract) mmhos / 1 cm / 25°C	0.75
Organic matter %	2.25
Total CaCO ₃ %	1.95
Available macronutrients (ppm)	
N	80.0
P	6.0
K	420.0
Ca	71.0
Mg	5.0
DPTA extractable available micronutrients (ppm)	
Zn	5.2
Fe	6.1
Mn	4.2
Cu	0.6

This experiment included the following seven treatments:

- 1- Control (normal horticultural practices).
- 2- Soil addition of calcium nitrate (15.5%N) at 1 kg/tree /year.
- 3- Spraying chelated calcium at 0.03%
- 4- Soil addition of borax (17%B) at 25 g/tree/year.
- 5- Spraying chelated boron at 0.025%
- 6- Soil addition of calcium nitrate at 1.0 kg/ tree / year + borax at 25g/tree/year.

- 7- Spraying chelated calcium at 0.03%+ chelated boron at 0.25 %.

Each treatment was replicated three times, one tree per each. Soil and foliar applications of calcium and boron at the prementioned levels and concentration were carried out three times at growth start (1st week of March), just after fruit setting (last week of April) and three week later (3rd week of May). Triton B as a wetting agent was added at 0.05% to all foliage solutions of calcium and boron and sprayed was done till runoff. Randomized complete block design was followed.

During both seasons, the following measurements were followed.

- 1- Some vegetative growth characters namely shoot length (cm), shoot thickness (cm) and leaf area (cm)² (**Ahmed and Morsy, 1999**) in the Spring growth cycle (first week of September).
- 2- Leaf pigments namely chlorophylls a & b, total chlorophylls and total carotenoids (as mg/ 100 g F.W.), first week of September (**Von-Wettstein, 1957 and Hiscox and Isralstam, 1979**).
- 3- Percentages of N, P, K, Mg and Ca in the leaves of non fruiting shoots in the Spring growth cycle first week of September (**Summer, 1985 and Wilde et al 1985**).
- 4- Percentage of initial fruit setting was calculated by dividing the number of setted fruits by total number of flowers at full bloom multiplied by 100.
- 5- Percentage of fruit retention was calculated by dividing the number of setted fruits at the first week of September by the total number of setted fruits at initial fruit set stage multiplied by 100.
- 6- Percentage of fruit drop was calculated by dividing the number of dropped fruits by the total number of setted fruits at initial fruit set stage multiplied by 100.
- 7- Yield expressed in weight / tree (kg.) and number of fruits /tree when T.S.S./Acid reached 8:1 (middle of December).
- 8- Physical characters of the fruits namely weight (g.), volume (cm³), **height** and diameter (cm) of fruit, percentages of fruit peel weight and pulp and fruit peel thickness (cm).
- 9- Chemical characteristics of the fruits namely T.S.S.%, total acidity % (as g citric acid/ 100 ml juice, **A.O.A.C., 2000**), total and reducing sugars % (**Lane and Eynon Method, 1965 and A.O.A.C., 2000**) and vitamin C (as mg / 100 ml juice, **A.O.A.C., 2000**).

Statistical analysis was done using new L.S.D. at 5% for making all comparisons among the seven treatment means (Mead et al 1993).

RESULTS AND DISCUSSION

1- Growth characters

It is clear from the data in **Table (2)** that single and combined applications of calcium via soil at 1.0 kg calcium nitrate / tree and via foliage as chelated –Ca at 0.03 % as well as boron via soil at 25 g borax / tree and via foliage as chelated –B at 0.025% significantly was accompanied with enhancing length and thickness of shoot and leaf area over the check treatment. Using calcium via chelated form through leaves significantly was superior than using it via soil as calcium nitrate. Foliar application of chelated B significantly enhanced all growth characters rather than using borax via soil. Using both Ca and B via leaves significantly surpassed the application of both via soil in this respect. The maximum shoot length (7.9 & 7.5 cm) and thickness (0.22 & 0.21 cm) as well as leaf area (31.6 & 31.5 cm²) were recorded on the trees that received chelated –Ca at 0.03 % besides chelated –B at 0.025% three times via foliage. Untreated trees produced the minimum values. These results were true during both seasons.

2- Leaf chemical composition

Data in **Tables (2 & 3)** clearly show that soil and foliar applications of Ca and B applied singly or in combinations significantly enhanced chlorophylls a & b, total chlorophylls and total carotenoids as well as percentages of N, P, K, Mg and Ca in the leaves over the check treatment.

Concerning methods of applications, using Ca and B via leaves significantly was superior than using each nutrient via soil in enhancing these plant pigments and different nutrients. Using chelated sources of Ca and B significantly was favourable than using Ca via calcium nitrate and B via borax in enhancing these organic and mineral nutrients. Spraying chelated –Ca at 0.03%, chelated –B at 0.025%, soil addition of borax at 25 g / tree and calcium nitrate at 1.00 kg / tree , in descending order was significantly effective in enhancing pigments and nutrients in the leaves. Combined application of both nutrients via soil and foliage significantly improved pigments and nutrients in the leaves than using each source and method of application alone. Folia application of Ca and B in

chelated form significantly surpassed the application of each via soil. Treating the trees with chelated –Ca at 0.03 % plus chelated –B at 0.025% gave the maximum values of total chlorophylls (11.0 & 11.0 mg/ 100 g F.W.) total carotenoids (3.1 & 3.2 mg), N (2.22 & 2.23 %), P (0.29 & 0.30%), K (1.60 & 1.61 %), Mg (0.82 & 0.83%) and Ca (2.64 & 2.81 %) during both seasons, respectively. The untreated trees produced the minimum values. These results were true during both seasons.

3- Fruit setting %, June dropping % and yield / tree

It is evident from the data in **Table (4)** that all Ca and B treatments significantly promoted the percentages of initial fruit setting and fruit retention and yield expressed in weight (kg.) and number of fruits trees per tree over the check treatment. A significant reduction on the percentage of June fruit dropping was observed due to the present Ca and B treatments rather than non-application. Foliar application method for both Ca and B significantly was superior than the soil one in improving fruit setting % and yield and reducing June fruit dropping. The best single application was using Ca via foliage followed by using B via leaves. Soil addition of Ca via calcium nitrate at 1.0 kg/ tree occupied the last position in this respect. Generally, using both nutrients together via soil or via foliage significantly superior than using each nutrient alone in any source or method of application. Foliar application of both nutrients via chelated forms significantly was superior than using both via soil in this respect. Spraying Washington Navel orange trees three times with a mixture of Ca and B in chelated form gave the maximum values of initial fruit setting (4.66 & 4.81 %); fruit retention % (1.46 & 1.48 %) and yield (77.0 & 84.0 kg) and the minimum June fruit dropping (0.8 & 0.6%) during both seasons, respectively. The untreated trees produced the minimum values of initial fruit setting, fruit retention and yield and the maximum June fruit dropping %. These results were true during both seasons.

4- Fruit quality

Data in **Tables (5 & 6)** reveal that all Ca and B treatments significantly were very effective in improving fruit quality in terms of increasing weight , size , height and diameter of fruit , pulp %, T.S.S.; total and reducing sugars % and vitamin C content and decreasing fruit peel weight and thickness and

total acidity % over the control treatment. Using both Ca and B via leaves significantly was superior than using both via soil in improving fruit quality. Spraying chelated-Ca gave the best results followed by spraying chelated –B. Soil addition of calcium nitrate occupied the last position in this respect. Combined application of Ca and B either applied via foliage or via soil significantly surpassed the application of each nutrient alone. The best results with regard to fruit quality were obtained due to treating the trees three times with a mixture of Ca and B in chelated form. The untreated trees gave unfavourable effects on fruit quality. These results were true during both seasons.

DISCUSSION

The beneficial effects of calcium on fruiting of Washington Navel orange trees might be attributed to its important action on enhancing cell division, N fixation, nutrient uptake, activity of enzymes and root development (Nijjar, 1985).

These results are in agreement with those obtained by Ahmed et al (2001); Jutamence et al (2002); Abdallah (2006) and Hassna-Huda (2014).

The important roles of boron on enhancing the cell division, pollen germination, uptake of water and nutrients as well as the biosynthesis and translocation of sugars (Perica et al 2001 and Ahmed et al 2009) could explain the present results.

The great variation on fruiting of the trees in response to varying methods and sources of application might be attributed to the change in uptake and availability of Ca and B under such conditions. These results are in agreement with those obtained by Gamal (2013); Ahmed et al (2013) and Abd El-Wahab (2015).

CONCLUSION

The best results with regard to yield and fruit quality of Washington Navel range trees were obtained owing to spraying the trees three times with a mixture of chelated-Ca at 0.03 % and chelated – B at 0.025%.

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