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Effect of Spraying Some Macro and Micro Nutrients on Fruit Set, Yield and Fruit Quality of Washington Navel Orange Trees

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Abstract: Washington navel orange trees grown on clay soil at El-Shohada district, Menofiya governorate, Egypt, were sprayed with some macro and micro nutrients to improve yield and fruit quality. Potassium di-hydrogen phosphate at 1%, calcium chelate at 0.5% and boric acid 300 ppm were sprayed once at full bloom stage either as a single or in combination treatments. Leaf mineral content, fruit set, yield and fruit quality were studied. Results indicated that spraying nutrients increased N, P and K content in the leaves compared with the untreated trees. Fruit set, yield as number of fruits and weight (kg) per tree were significantly improved by different nutrient treatments specially when sprayed at various combinations, also fruit quality was improved by spraying different nutrients. However, spraying calcium chelate in combination with boric acid or potassium di-hydrogen phosphate seems to be the promising treatments under the condition of this investigation.

Key words: Macro and Micro nutrients, Washington navel orange, Fruit set, Fruit quality.

INTRODUCTION

It is well known that the largest fruit trees area in Egypt is planted with citrus. Washington navel orange is the leader of citrus in Egypt and is considered the most popular citrus fruits for the Egyptians. Trees may have the problem of low productivity due to the suffering of some macro or micro nutrients deficiencies.

Potassium as a macro nutrient plays a great regulatory role in many physiological and biochemical processes of plant. Potassium is important in the formation and functioning of proteins, fats, carbohydrates and chlorophyll and in maintaining the balance of salts and water in plant cells[4]. Moreover, many investigators proved that potassium increased fruit set %, fruiting % and yield of orange trees.

Phosphorus performs many vital functions in the plant in photosynthesis, in enzyme activity and in the formation and movement of sugars. It is important in flowers and developing fruit.

Calcium promotes early root formation and growth, improves general plant vigor, stiffness of stalks and improves fruit integrity. Calcium influences the uptake of other nutrients such as phosphorous, manganese, iron, zinc and boron, Polevoiy[19].

Boron as a micro nutrient plays an important role in g rowth behavior and productivity of trees. It increases pollen grains germination and pollen tube elongation, consequently fruit set percentage and finally the yield.

Many previous studies revealed that macro and micro nutrients foliar sprays enhanced nutrional status and improved the yield and quality of different fruit crops. These studies were supported by Shawky *et al.*[24], El-Deeb[11], EL-Saida[13], Abd-EL-Migeed[1] on oranges; Chanturiya[7], Ibrahim *et al.*[15], El-Fangary[12] on mandarin; Dabas& Jindal[9] on grapevines; Shaheen[23], Osman[18], Hassan[14], Abd El-Migeed *et al.*[3] on olive.

Therefore, this experiment was carried out in a trial to improve productivity and fruit quality of Washington navel orange grown at El-Shohada district through foliar sprays containing some macro and micro nutrients namely phosphorus, potassium, calcium and boron.

MATERIALS AND METHODS

This study was carried out during two successive seasons (2004 and 2005) on 25 years old Washington navel orange trees, budded on sour orange rootstock and planted at 5x5 meters on clay soil under basin irrigation system in a private orchard at El-Shohada district, Menofiya governorate.Eight spraying treatments were done at full bloom stage as follows:

- Control (sprayed with water only).
- Calcium chelate at 0.5%.
- Boric acid at 300 ppm.
- Di-potassium hydrogen phosphate (K_2HPO_4) at 1%. Calcium chelate 0.5% + boric acid at 300 ppm.

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- Calcium chelate 0.5% + di-potassium hydrogen phosphate 1%.
- Boric acid 300 ppm + di-potassium hydrogen phosphate 1%.
- Calcium chelate 0.5% + di-potassium hydrogen phosphate 1% + boric acid at 300 ppm.

The other cultural practices were the same for all trees. Each treatment was replicated four times on one tree plots and the randomized complete block design was arranged.

To determine leaf mineral content, about forty leaves were taken in late August in each season from tagged non fruiting and non flushing spring growth cycle[16]. Leaf samples were washed with tap water, then with distilled water and dried at 70°C, finally ground and digested. The digested solution was used to determine N, P and K content as percentage on dry weight bases using the methods described by Cottenie *et. al.*[8].

Number of fruit set/branch was calculated at early May of each season.

Yield was determined at harvest time (late December) as number of fruits and weight (kg)/tree. For fruit quality, a sample of ten fruits from each tree was taken to determine average fruit weight, peel thickness, Juice weight, total soluble solids percentage and titratable acidity content using the methods described in A.O.A.S.[5].

The data were subjected to analysis of variance and Duncan's multiple range test was used to differentiate means[10].

RESULTS AND DISCUSSIONS

Leaf mineral content: Results in Table (1) showed the effect of different treatments on nitrogen, phosphorus and potassium content in the leaf:

Nitrogen was significantly affected by different treatments compared with the control in both studied seasons. In this respect, the highest N% in the first and second seasons was recorded by di-potassium hydrogen phosphate (K_2HPO_4) treatment solely, while the lowest N% was recorded by the control.

Phosphorus content in the leaves was significantly affected in both seasons. Generally, all treatments enhanced phosphorus content in the leaves compared with the control and the highest value was recorded by K_2HPO_4 solely and calcium chelate + K_2HPO_4 treatments in the first and second seasons, respectively, While the control gave the lowest value.

Potassium percentage in the leaves was significantly affected in the first season only since, the treatments included K_2HPO_4 increased K value than the control and the highest percent was recorded by spraying K_2HPO_4 solely.

The previous results are in agreed with that obtained by Abd El-Migeed *et al.*[2] who reported that mineral status of Hamlin orange trees with respect to N, P and K content in the leaves could be markedly enhanced by NPK sprays specially at 0.5% urea +1 or 1.5% K_2HPO_4. Saleh and Eman[22] found that spraying potassium citrate at 0.3% alone raised potassium content in the leaves of mango. Meanwhile, the presence of boric acid at any concentration with potassium citrate increased nitrogen and potassium content in the leaves.

Fruit set and yield: Table (2) showed the effect of different treatments on fruit set and yield as fruit number and yield weight/tree.

As for fruit set number per branch, spraying each nutrient alone increased this parameter than the control and the great increment was observed when each nutrient was combined with the others. In this respect, boric acid

Table 1: Nitrogen, phosphorus and potassium content in the leaves of Washington navel orange trees as affected by macro and micro nutrients sprays in 2004 and 2005 seasons.

	N %		P %		K %	
Treatments	2004	2005	2004	2005	2004	2005
Control	2.22c	2.06b	0.09b	0.08b	0.51b	0.49
*Ca. ch. 0.5%	2.71ab	2.60a	0.10b	0.11a	0.54ab	0.51
Boric acid 300ppm	2.67ab	2.55a	0.12b	0.10ab	0.51b	0.52
**K_2HPO_4 1%	2.77a	2.73a	0.16a	0.12a	0.68a	0.57
Boric acid + Ca. ch.	2.52abc	2.59a	0.11b	0.11a	0.55ab	0.56
K_2HPO_4 + Ca. ch.	2.50abc	2.32ab	0.11b	0.13a	0.58ab	0.56
Boric acid + K_2HPO_4	2.40bc	2.30ab	0.11b	0.11a	0.58ab	0.59
Boric acid + K_2HPO_4 + Ca.ch.	2.74ab	2.47ab	0.12b	0.11a	0.58ab	0.60
Significance at 5% level	S	S	S	S	S	N.S.

*Ca. ch = calcium chelate.
** K_2HPO_4 = di-potassium hydrogen phosphate.

Table 2: Fruit set, number of fruits per tree and yield weight per tree of Washington navel orange trees as affected by macro and micro nutrients sprays in 2004 and 2005 seasons.

Treatments	No. of fruit set/ branch		No. of fruits/tree		Yield/tree(kg)		Average yield (kg)/ tree of the two seasons
	2004	2005	2004	2005	2004	2005	
Control	92c	114b	323d	321d	81b	75e	78b
*Ca. ch. 0.5%	134b	124b	328d	320d	76b	73c	74b
Boric acid 300ppm	134b	119b	322d	338cd	85b	85cd	85b
**K_2HPO_4 1%	118bc	134b	324d	356c	77b	80de	79b
Boric acid + Ca. ch.	191a	134b	462a	441a	120a	101b	110a
K_2HPO_4 + Ca. ch.	185a	187a	437b	412b	108a	113a	110a
Boric acid + K_2HPO_4	188a	191a	439b	413b	120a	91c	105a
Boric acid + K_2HPO_4 + Ca.ch.	143b	134b	421c	405b	110a	102b	106a
Significance at 5% level	S	S	S	S	S	S	S

*Ca. ch = calcium chelate.
** K_2HPO_4 = di-potassium hydrogen phosphate.

Table 3: Physical and chemical properties of Washington navel orange fruits as affected by macro and micro nutrients sprays in 2004 and 2005 seasons.

Treatments	Fruit weight (gm)		Peel thickness (cm)		Juice weight (gm)		TSS %		Acidity %		TSS/acid ratio	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Control	253	235bc	0.58bcd	0.70ab	102ab	100	13.6b	13.0c	0.88e	0.92c	10.6de	10.6c
*Ca. ch. 0.5%	232	229bc	0.61abc	0.60bc	87b	96	13.6b	13.0c	0.96d	0.91c	10.1e	10.0c
Boric acid 300ppm	265	252abc	0.50d	0.61abc	108a	105	13.8ab	14.0ab	0.83e	1.01bc	10.3e	10.7c
**K_2HPO_4 1%	240	226bc	0.70a	0.60bc	85b	84	14.6a	14.3a	1.38a	1.27a	11.9d	12.96b
Boric acid + Ca. ch.	259	230bc	0.58bcd	0.71a	104ab	110	14.2a	14.3a	0.83e	0.92c	14.2c	14.4ab
K_2HPO_4 + Ca. ch.	248	275a	0.66ab	0.56c	94ab	100	13.4b	13.0c	1.32b	1.30a	16.6ab	13.8ab
Boric acid + K_2HPO_4	273	220c	0.53cd	0.53cd	111a	111	13.4b	13.6b	1.30b	1.28a	17.2a	15.6a
Boric acid + K_2HPO_4 + Ca.ch.	261	255ab	0.60abcd	0.63abc	101ab	111	13.3ab	14.3a	1.20c	1.11b	15.5bc	14.4ab
Significance at 5% level	NS	S	S	S	S	NS	S	S	S	S	S	S

*Ca. ch = calcium chelate.
** K_2HPO_4 = di-potassium hydrogen phosphate.

+ Ca. chelate and boric acid + K_2HPO_4 treatments gave the higher numbers of fruit set per branch in the first and second seasons, respectively compared with the other treatments.

Regarding yield as number of fruits per tree, it is clear that the combination between the nutrients increased number of fruits and recorded the high values compared with the single treatment of each nutrient in addition to the control. However, boric acid + Ca. chelate treatment gave the highest number of fruits in both studied seasons.

Concerning yield weight (kg) per tree, similar trend was observed, since the combination between nutrients improved the yield of trees significantly than the control. In this respect, presence boric acid with calcium chelate or K_2HPO_4 in the same solution gave high weight in the first season, while in the second season, K_2HPO_4 + calcium chelate treatment gave the highest weight per tree compared with the other treatments.

To avoid the effect of seasons, the average yield weight (kg) per tree of the two seasons was calculated. In this respect, results indicated that the treatments included the combinations between the nutrients under investigation significantly increased yield and gave the higher values comparing with the single sprays of each nutrient or the untreated trees and no differences were detected between the combination treatments.

In respect to the previous results, Hassan[14] reported that the improvement in fruit set % of olive could be explained as a result to increase pollen grains germination and pollen tube elongation due to boron treatments. Saleh and Eman[22] found that spraying potassium citrate enhanced fruit set number of mango, while presence of

potassium citrate and boric acid together in the same solution had a positive effect on increasing fruit set, fruit retention, decreasing fruit drop and consequently increased yield as weight or number of fruits/tree. Also the previous results are in line with those obtained by Oothuyes[7] on mango, Qin[20], Abd El-Migeed *et al.*[2] and Saleh *et al.*[21] on orange, Abd El-Migeed *et al.*[3] on olive, who reported that yield of mango, orange and olive were increased by potassium, phosphorus and boron applications.

Fruit quality: Table (3) showed the effect of different treatments on physical and chemical fruit properties.

Fruit weight was significantly increased in the second season only, since the highest value was obtained with Ca. chelate + K_2HPO_4 treatment comparing with the other treatments including the control.

Peel thickness was significantly affected by treatments. K_2HPO_4 treatment alone followed by Ca. chelate + K_2HPO_4 gave the higher values in the first season. While in the second season, boric acid + Ca. chelate treatment followed by the control recorded the higher thickness of the peel.

Regarding juice weight, treatments significantly increased it in the first season only, since boric acid + K_2HPO_4 treatment recorded the highest juice weight followed by Ca. chelate + boric acid.

As for total soluble solids (TSS), K_2HPO_4 treatment solely recorded the highest value in the first season and the same treatment beside boric acid + Ca. chelate and the combination of the three nutrients treatments recorded similar higher values in the second season.

Acidity percentage in the fruit juice was significantly increased by K_2HPO_4 treatment followed by the treatments containing K_2HPO_4. This was true in the first season, while in the second one, more or less the same trend was occurred.

TSS/acid ratio significantly affected by treatments since Ca. chelate + boric acid treatment recorded the highest value in both studied seasons followed by boric acid alone and control plants.

These results are in harmony with those obtained by Bhuyan and Irabagon[6], Oosthuyes[17], Saleh and Eman[22] on mango, Qin[20], Abd El-Migeed *et al.*[2], Saleh *et al.*[21] on orange, who reported that average fruit weight, fruit size, peel thickness, juice weight, juice % and TSS were improved by potassium, phosphorus or boron applications.

The increment in yield weight per tree due to the previous treatments may be explained as a positive effect of the treatments specially the combination between the sprayed nutrients on leaf mineral contents, fruit set, consequently number of fruits per tree besides improving fruit weight.

From the abovementioned results, it could be concluded that, spraying Washington navel orange trees with potassium, phosphorus, calcium and boron as macro or micro nutrients have a positive effect on leaf mineral content, fruit set, yield and fruit quality. In this respect, it seems that, using any combined treatment may be considered as a promising treatment specially calcium chelate + boric acid or calcium chelate + di-potassium hydrogen phosphate.

REFERENCES

1. Abd EL-Migeed, M.M., 1996. Effect of Some Macro and Micro Nutrients on Mineral Content, Productivity and Fruit Quality of Navel Orange Trees. Ph.D.Thesis in Pomology, Fac. Agric., Ain Shams Univ., Cairo, Egypt, pp: 26-89.
2. Abd-El-Migeed, M.M.M., E.A.M. Mostafa and M.M.S. Saleh, 2000. Effect of some macro nutrients sprays on mineral status, yield and fruit quality of Hamlin orange trees grown under Rafah conditions. J. Agric. Sci. Mansoura Univ., 25: 403-411, Egypt.
3. Abd EL-Migeed, M.M.M., M.M.S. Saleh, E.A.M. Mostafa and M.S. Abou –Raya, 2002. Influence of soil and foliar applications of boron on growth, fruit set, mineral status, yield and fruit quality of Picual olive trees. Egypt. J. Appl. Sci., 17: 261-272.
4. Achilea, O., 1998. Citrus and tomato quality is improved by optimized K nutrition. In: Improved Crop Quality by Nutrient Management. Anac, D. and P. Martin- prevel (eds). Kluwer Academic Publishers. pp: 19-22.
5. A.O.A.C., 1975. Association of Official Agricultural Chemists. Official Methods of Analysis, 12th ed., P.O. Box 450, Benjamin Franklin Station, Washington, D.C., pp: 832.
6. Bhuyan, M.A.J. and J.A. Irabagon, 1992. Effect of fertilizer, potassium nitrate sprays and irrigation on the physic-chemical compostion of mango (mangifera indica L.) fruit cv. Carabao. South Indian Hort. 40: 9 - 15.
7. Chanturiya, I.A., 1972. Trials with different boron rates in mandarin plantation. Suptropicheskie Kul Tury, (1), 78-81 (Hort. Abst., 43: 6344).
8. Cottenie, A., M. Verloo, L. Kiekens, G. Velgle and R. Camerlynuck, 1982. Chemical Analysis of Plant and Soil, 43- 51. Laboratory of Analytical and Agroch. State Univ. Belgium, Gent.
9. Dabas, A.S. and P.C. Jindal, 1987. Effect of boron and magnesium sprays on bud formation, berry set and berry drop of grapes. J. Agric. Res. 19: 40-44. (Hort. Abst., 57: 280).

10. Duncan, D.B., 1955. Multiple range and multiple "F" tests. Biometrics, 11: 1-42.
11. El-Deeb, M.D.E., 1989. Studies on the nutritional status of citrus in some areas of Kaliobai. Ph.D. Thesis. Fac. Of Agric. Moshtohor. Zagazig Univ.
12. El-Fangary, M.A., 1998. Physiological studies on growth and fruiting of citrus trees. Ph.D. Thesis Fac. Agric. Moshtohor Zagzig Univ.
13. El-Saida, S.A.G., 1996. Physiological Studies on Nutrition in Citrus. Ph.D. Thesis, Fac. Agric., Menofiya Univ. pp: 62-157.
14. Hassan, S.A., 2000. Morphological and physiological studies on flowering, pollination and fruiting of Picual olive trees. Ph.D. Thesis, Fac. of Agric., Cairo Univ., Egypt, pp: 111.
15. Ibraheim, T.A., F.F. Ahmed and K.G. Assy, 1993. Behaviour of Balady mandarin trees, (Citrus reticulata L.) growing in sandy soil to different forms and concentrations of potassium foliar sprays. Assuit J. of Agric. Sci. Vol. 24: 3.
16. Jones, W.W. and T.W. Embleton, 1960. Leaf analysis- nitrogen control program for oranges. Calif. Citrogr., 45: 349- 353 (c.f. Hort. Abst. 31: 3128).
17. Oosthuyes, S.A., 1993. Effect of spraying application of KNo3, urea and growth regulators on the yield of Tommy Atkins mango. South African Mango Growers Association (Yearbook), 13: 58-62.
18. Osman, L.H., 1999. Response of Picual olive trees to soil fertilization with Borax and Magnesium sulphate. Minufiya, J. Agric. Res., Vol. 24 (1999). No. 1: 277-287.
19. Polevoiy, V.V., 1989. Calcium-related physiological disorders of plants. Ann. Rev. Phytopathol. 17: 97-122.
20. Qin, X., 1996. Foliar spray of B, Zn and Mg and their effects on fruit production and quality of Jincheng orange (citrus sinensis). Journal of Southwest Agricultural Univ. 18: 40- 45.
21. Saleh, M.M.S., E.A.M. Mostafa and M.M.M. Abd El-Migeed, 2001. Response of some orange cultivars to different rates of potassium fertilization under sandy soil conditions. Annals Agric. Sci., Ain Shams Univ., 46: 861-873, Egypt.
22. Saleh, M.M.S. and Eman, A.A. Abd El-Monem, 2003. Improving productivity of "Fagri Kalan" mango trees grown under sandy soil conditions using potassium, boron and sucrose as foliar spray. Annals Agric. Sci., Ain Shams Univ., 48: 747-756, Egypt.
23. Shaheen, S.A.A., 1995. Effect of foliar sprays of some nutrients on flowering and fruiting of olive trees. M.Sc. Thesis. Fac. of Agric., Cairo Univ. pp: 122.
24. Shawky, I., Z. Zidan and S. Maximos, 1970. Nitrogen, phosphorus and potassium sprays on Balady orange trees. Research Bulletin 178 (B) 1970. Plant Production Dept., Faculty of Agric., Ain Shams Univ.