Emir. J. Food Agric. 2011. 23 (1): 95-102
http://ejfa.info

Short Communication

Enhancing cropping of Navel orange by different agrochemicals foliar sprays

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Abstract: The present investigation was carried out during the two successive growing seasons of 2003 and 2004 on Washington Navel orange trees grown at El-Tarh region, El-Behera Governorate of Egypt. In order to study the effect of spraying the trees with different agrochemicals on vegetative growth, fruit drop, fruit retention and yield. Trees were divided into two groups , the first group was subjected to the foliage treatments when the fruit reached pea size (5 mm in diameter) and the second group at marble size (15 mm in diameter). Foliar sprays of urea or 2, 4-D alone at pea or marble stage significantly increased vegetative growth. In general, foliar sprays of 2, 4-D alone or with the different calcium compounds at pea or marble stage significantly increased fruit retention and decreased fruit drop after June drop. Final fruit retention was increased (23 - 69% over the control) and pre-harvest fruit drop was decreased (63 to 100% compared to the control) by spraying boric acid or 2, 4-D alone at the pea stage in both seasons. Spraying calcium superphosphate alone at the marble stage caused an increase in final fruit retention by 33 - 7% and a decrease in pre-harvest fruit drop by 61 -72% over the control in both seasons.

Keywords: Navel orange, agrochemicals, fruit drop, fruit retention, yield.

تحسين محصول البرتقال أبو سرة بواسطة الرش الورقى ببعض الكيماويات الزراعية

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الملخص :أجريت هذه الدراسة خلال موسمى النمو 2003و2004 على أشجار البرتقال أبو سرة في أحد مزارع محافظة البحيرة بمنطقة الطرح، وذلك بغرض دراسة تأثير الرش الورقي في مرحلتين من نمو الثمار ببعض الكيماويات الزراعية على النمو الخضرى ونسبه تساقط وبقاء الثمار والمحصول، وقد أجريت الدراسة على 96 شجرة متماثلة وموزعة عشوائياً في الحقل مقسمة إلى مجموعتين . رشت المجموعة الأولى فى مرحلة حجم البسله (قطر 5مم)، ورشت المجموعة الثانية فى مرحلة حجم البلية (قطر15مم) أدى الرش بكل من اليوريا و 2,4-D فى مرحلتى النمو إلى زيادة النمو الخضرى زيادة معنوية بالمقارنة بالكنترول عموما الرش بالـ 2,4-D سواء منفردا أو مع مركبات الكالسيوم المختلفة فى مرحلتى النمو أدى إلى زيادة بقاء الثمار وخفض نسبة التساقط بعد تساقط يونيو منفردين فى مرحلة البسلة يؤدي الى زيادة معنوية D-رش حمض البوريك أو 2,4 . %لبقاء النهائية للثمار (23 و69%) و خفض نسبة تساقط الثمار قبل الجمع (63 و 100فى نسبة ا خلال عامي الدراسة بالمقانة بالكنترول . كذلك رش سوبرفوسفات الكالسيوم فى مرحلة البلية (يؤدي الى زيادة معنوية فى نسبة البقاء النهائية للثمار (33 و 7%) و انخفاض نسبة تساقط الثمار بل الجمع (61 و 72%) خلال عامي الدراسة بالمقارنة بالكنترولق.

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Introduction

Orange (*Citrus sinensis* L.) is considered as one of the major citrus fruit crops in Egypt. The Navel orange plays a dominant role not only in the local market, but also for exportation. However, the problem of June drop and pre-harvest fruit drop is extensive in many Egyptian orchards, especially because Navel orange is a parthenocarpic cultivar thus, eliminating yield and fruit quality. Pre-harvest drop occurs after the fruit have reached legal maturity but prior to harvest. Since pre-harvest drop involves abscission of mature fruit, this problem is very disturbing to growers. The problem is most severe for Navel orange and grapefruit when held on the tree late into the season. The use of growth regulators such as 2, 4-D to decrease the different types of fruit drop in citrus trees has been studied for many years (Anthony and Coggins, 1999; Kaur et al., 2000; Saleem et al., 2007).

In accordance to the above observation, one of the most important factor that has a great effect on fruit drop is the nutritional status of the tree. There were different fertilization researches carried out in order to improve the yield and quality of citrus fruit crops in Egypt (El-Gazzar et al., 1979; Marzouk and Kassem, 2002). Foliar sprays of calcium, boron and zinc either alone or in combinations, have been shown to protect the plant against stress (Andrews, 2002). Stress (ie high temperature stress) disrupts tree metabolism and cause physiological damage such as fruit drop. In addition, Davies (1986) remarked that Navel oranges are more susceptible to environmental stress than other sweet oranges and observed an increase in fruit drop during the summer. Accordingly, June drop of Navel orange in Egypt might be controlled by foliar sprays of calcium and or boron. However, date and number of applications must be considered to obtain best results.

In respect of the above consideration, the present study was carried out in order to investigate the influence of different agrochemicals foliar sprays either alone or in combinations to Navel orange trees during two growing stages of the fruit (at pea and marble stages) on fruit drop and retention after June drop, pre-harvest fruit drop and retention and the yield of Washington Navel orange trees grown in a clay soil.

Materials and methods

Plant material and treatments

The effect of spraying Washington Navel orange trees with different agrochemicals on fruit drop, fruit retention and yield was studied during 2003 and 2004 growing seasons. The present study was conducted in a private citrus orchard at El-Tarh region, EL-Behera Governorate. The soil was clay, well-drained with water table at 120 cm approximately and pH 8. Twenty years old Washington Navel orange trees (*Citrus sinensis*, L.), budded on sour orange rootstock were planted at 4x4 m apart and subjected to the same cultural practices usually done in the orchard

In January of both seasons, calcium superphosphate (155% P_2O_5) was added at the rate of 500 kg per feddan. Ammonium nitrate (33% N) was applied at the rate of 300 kg in March, 250 kg in May and 300 kg in August of both seasons per feddan. In August of both seasons, 100 kg per feddan potassium sulfate (48% K_2O_5) was added. Trees were irrigated with Nile water every 15-20 days.

For the present study, 96 trees were selected as uniform as possible and divided into two groups. The first group was subjected to the foliage treatments in early May when fruits reached pea size (15mm in diameter) and the second in late May when fruits reached marble size (25 mm in diameter). Trees were sprayed with, calcium chloride (0.5%), calcium acetate (0.5%), boric acid (150 ppm), urea (2%), calcium superphosphate (2%) and 2,4-D (20 ppm) 2,4-D was sprayed alone or in

combination with the previous mentioned compounds.

Treatments were arranged in a complete randomized design with four replicates for each treatment and trees of both groups were treated with the following 12 foliage treatments (ie, 4 x 12 = 48 trees/group):

T1 = Water spray only (control)
T2 = Calcium chloride (0.5%)
T3 = Calcium acetate (0.5%)
T4 = Boric acid (150 ppm)
T5 = Urea (2%)
T6 =Calcium superphosphate (2%)
T7 = 2, 4-D (20 ppm)
T8 = 2, 4-D (20 ppm) + calcium chloride (05 %)
T9 = 2, 4-D (20 ppm) + calcium acetate (05%)
T10 = 2, 4-D (20 ppm) + boric acid (150 ppm)
T11 = 2, 4-D (20 ppm) + urea (2%)
T12 = 2, 4-D (20 ppm) + calcium superphosphate (2%)

The surfactant Nourfilm (produced by Alam Chemca) at the rate of 40 cm/100 L water was added to all sprayed chemicals in order to obtain best results.

Vegetative growth and yield components

In order to study the effect of the different treatments on tree growth, three main branches were tagged from the different sides of each tree in early May for pea stage and late May for marble stage. The length of spring non-fruiting shoots per branch was recorded in November of both seasons. In addition, the number of fruits on the previous tagged branches was counted and recorded at every spraying date and after June drop. The fruit retention percent after June drop and at harvest (final fruit retention) was calculated during both seasons. Similarly, fruit drop after June drop and at harvest time (pre-harvest drop) was also calculated:

A- After June drop (July)

Fruit retention (%) =No of fruits after June drop/ No of fruit at spraying date × 100.

Fruit drop (%) = 100 – % Fruit retention.

B- At harvest time (December)

Final Fruit retention (%) = No of fruits at harvest / No of fruits after June drop × 100.

Preharvest drop (%) = 100 – % final fruit retention.

The yield was recorded at harvest date in December of 2003 and 2004 seasons, expressed as weight (kg/tree) and number of fruits per tree.

Statistical analysis

The data were statistically analyzed according to the method of Snedecor and Cochran (1980).

Results

Vegetative growth

As for the pea stage, the data presented in Table (1) showed that spraying urea alone urea + 2,4-D, 2,4-D alone and 2,4-D + calcium superphosphate significantly increased shoot length by 66, 51, 37 and 31% in the first season and by 87, 67, 48 and 39% in the second season, respectively compared to the control.

Regarding the marble stage, shoot length was significantly increased by spraying urea alone and 2,4-D alone, at both seasons and boric acid in the first season only as compared with the control. In addition, spraying urea alone resulted in an increase in shoot length by 84 % in the first season and 58 % in the second season over the control.

Fruit retention

Regarding the pea stage, the data presented in Tables (1 and 2) showed that spraying boric acid alone, calcium superphosphate alone, 2,4-D + calcium chloride, 2,4-D + calcium acetate , 2,4-D + boric acid, 2,4-D + urea and 2,4-D + calcium superphosphate significantly increased the

percentage of fruit retained after June drop as compared with the control at both seasons. The increase ranged between 50 - 123% in the first season and 46 - 101% in the second season for the above mentioned treatments over the control. As for final fruit retention, it was significantly increased by spraying boric acid, urea, or 2, 4-D alone at both seasons in comparison with the control. The increase over the control ranged between 16 and 69% for both seasons.

Table 1. Effect of spraying different agricultural chemicals on shoot length, fruit retention and fruit drop of Navel orange trees in 2003and 2004 seasons.

Treatments	Shoot length (cm)		Fruit retention after June drop (%)		June drop (%)	
	Pea stage	Marble stage	Pea stage	Marble stage	Pea stage	Marble Stage
			2003 year			
T1	19.94de	19.20b	12.70e	76.74c	87.30a	23.26a
T2	24.94bcd	24.40b	14.75de	92.47ab	85.25ab	75.3cd
T3	24.44cde	23.20b	15.65cde	87.51ab	84.35abc	12.49bc
T4	25.44bcd	29.40ab	21.75b	95.63a	78.25c	43.7d
T5	33.10a	35.30a	20.40bcd	92.37ab	79.60bcd	76.4cd
T6	21.94cde	22.90b	28.35a	90.32ab	71.65e	96.7cd
T7	27.22bc	29.30ab	15.35sde	92.40ab	84.15abc	75.9cd
T8	20.16de	22.05b	19.60bcd	88.81ab	80.40bc	11.19bcd
T9	23.71sde	25.80ab	19.05bcd	87.71ab	80.95bc	12.29bc
T10	18.99e	23.10b	19.30bcd	92.25ab	80.70bc	77.5cd
T11	30.11ab	22.20b	22.20b	84.94bc	77.80d	15.12bc
T12	26.21bc	24.90b	20.95bc	82.18c	79.05c	17.82ab
LSD0.05	5.51	10.08	5.77	8.59	6.11	7.91
			2004 year			
T1	14.55d	17.90c	20.40g	54.00b	79.60a	45.63a
T2	18.17cd	18.80c	23.90efg	75.00a	76.10ab	24.96b
T3	16.95cd	17.25c	22.50fg	72.20a	77.50ab	27.76b
T4	19.67bcd	19.25bc	29.70de	74.70a	70.30bcd	25.26b
T5	27.20a	28.25a	23.70efg	74.90a	76.30ab	25.06b
T6	16.32cd	18.92bc	29.45def	83.70a	70.55bc	16.30b
T7	21.55abc	22.12b	44.35a	84.70a	55.65g	15.25b
T8	19.57bcd	18.27c	32.70cd	77.30a	67.30cdef	22.66b
T9	18.85bcd	18.17c	40.00ab	76.30a	60.00efg	23.70b
T10	19.05bcd	17.30c	34.75bcd	77.00a	65.25cdef	23.00b
T11	24.27ab	20.17bc	37.90abc	73.90a	62.10defg	26.10b
T12	20.25bcd	17.27c	41.40a	72.40a	58.60fg	27.60b
LSD 0.05	5.70	3.20	6.44	13.30	8.40	15.00

Values followed by the same letter (s) in a column are not significantly different at p = 0.05 according to Snedecor and Cochran (1980).

With regard to the marble stage, spraying calcium chloride, calcium acetate , boric acid, urea, calcium superphosphate, 2,4-D alone, 2,4-D + calcium chloride, 2,4-D + calcium acetate and 2,4-D + boric acid significantly increased the fruit retention percentage after June drop over the control at both seasons. The increase ranged between 14 – 25% in the first season and 34 – 57% in the second season over the control. As for final fruit retention, foliar sprays of either calcium superphosphate or 2,4-D alone increased fruit retention percent as compared with the control at both seasons. Calcium superphosphate caused an increase of 33%

in the first season and 7% in the second season over the control 2, 4-D caused an increase of 35% in the first season and 32% in the second season over the control (Tables 1 and 2).

Table 2. Effect of spraying different agricultural chemicals on final fruit retention, preharvest fruit drop and yield of Navel orange trees in 2003and 2004 seasons.

Treatments	Final fruit retention (%)		Preharvest fruit drop (%)		Yield (kg/tree)	
	Pea stage	Marble stage	Pea stage	Marble stage	Pea stage	Marble stage
			2003 year			
T1	96.81efg	95.62d	3.19ab	4.38a	47e	55e
T2	95.80g	98.68abc	4.20a	1.32bc	53de	74abc
T3	95.80g	97.37bcd	4.20a	2.63ab	53de	67cd
T4	100.0a	98.42abc	0.00d	1.58bc	66a	80ab
T5	98.33bc	97.15bcd	1.67bcd	2.85ab	54d	82a
T6	97.30cde	98.78abc	2.70abc	1.22bc	66a	76abc
T7	99.01ab	98.92ab	0.99ce	1.08bc	65a	68cd
T8	98.29bc	97.00cd	1.71bcd	3.00ab	61abc	69bcd
T9	97.00def	98.00abc	3.00ab	2.00bc	58bcd	78abc
T10	97.88cd	99.52a	2.12bc	0.48c	55cd	78abc
T11	95.98fa	98.66abc	4.02a	1.34bc	64abc	66cda
T12	96.90def	98.44abc	3.10ab	1.56bc	66a	57de
LSD0.05	1.03	1.89	1.89	2.08	6.6	12.3
			2004 year			
T1	90.42cf	89.74def	9.58ab	10.26ab	46f	64 de
T2	93.38bcd	88.14fg	6.62abc	11.86a	64 cd	57e
T3	88.83f	94.74ab	11.17a	5.26cd	48 f	79c
T4	96.46ab	87.17g	3.54c	12.83	55 e	73cd
T5	94.34abc	95.55a	5.66bc	4.45d	58 de	93 ab
T6	91.52de	96.00a	8.48abc	4.00d	69 c	82bc
T7	96.68a	92.74bc	3.32c	7.26bcd	88 a	98a
T8	91.80cde	90.02def	8.20abc	9.98ab	69 c	57e
T9	91.61de	90.70cde	8.39abc	9.30abc	59 de	82 bc
T10	89.87ef	90.91ca	10.13ab	9.09abc	76 b	104a
T11	95.00ab	88.56efg	5.00bc	11.44a	69c	71 cde
T12	92.06cde	89.48def	7.94abc	10.52ab	69c	76cd
LSD0.05	2.62	2.13	5.40	3.92	6,3	14.2

Values followed by the same letter (s) in a column are not significantly different at p = 0.05 according to Snedecor and Cochran (1980).

Fruit drop

With regard to the pea stage, the data presented in Tables (1 and 2) indicated that the percentage of June drop was significantly decreased by spraying boric acid, calcium superphosphate, 2,4-D + calcium chloride, 2,4-D + calcium acetate , 2,4-D + boric acid, 2,4-D + urea and 2,4-D + calcium superphosphate, in both seasons. Moreover, calcium superphosphate gave better results than all treatments in the first season only. In addition, pre-harvest fruit drop was significantly decreased by spraying either boric acid or 2, 4-D alone compared with the control at both seasons. The decrease over the control was 100 and 96% in the first season and 63 and 65% in the second season for boric acid and 2,4-D

sprays indicating no significant difference between both substances.

Regarding the marble stage, the obtained data showed a significant decrease in June drop over the control by spraying calcium chloride, calcium acetate, boric acid, urea, calcium superphosphate, 2,4-D alone, 2,4-D + calcium chloride, 2,4-D + calcium acetate, 2,4-D + boric acid and 2,4-D + urea in both seasons. The decrease over the control ranged from 23 – 81% in the first season and from 39 – 67% in the second season. As for pr-harvest drop, it was significantly decreased by spraying calcium superphosphate alone at both seasons with an average decrease of both seasons over the control by 665%.

Yield

Regarding the pea stage, the data of both seasons indicated that spraying boric acid, urea, calcium superphosphate, 2,4-D alone, 2,4-D + calcium chloride, 2,4-D + calcium acetate, 2,4-D + boric acid, 2,4-D + urea and 2,4-D + calcium superphosphate significantly increased the yield when compared to the control (Tables 1 and 2).However, spraying calcium acetate alone did not affect the yield at both seasons. Moreover, the effect of spraying boric acid alone, calcium superphosphate, 2,4-D alone, 2,4-D + calcium chloride, 2,4-D + urea and 2,4-D + calcium superphosphate did not differ from each other and gave significantly higher effect than urea alone, in the first season only In the second season, foliar sprays of calcium superphosphate alone, 2,4-D alone, 2,4-D + calcium chloride, 2,4-D + boric acid, 2,4-D + urea and 2,4-D + calcium superphosphate gave better results than spraying urea alone, boric acid alone and 2,4-D + calcium acetate (Tables 3 and 4).

With regard to the marble stage, the data obtained indicated that the yield was significantly increased over the control by spraying calcium acetate, urea, calcium superphosphate, 2,4-D alone, 2,4-D + calcium acetate and 2,4-D + boric acid, at both seasons In addition, no significant differences between 2, 4-D + urea and 2, 4-D + calcium superphosphate at both seasons were obtained (Tables 1 and 2).

Discussion

The increase in shoot length resulting from urea spray may be related, it was shown that foliar applied urea represents an effective and most efficient method as a source of nitrogen in sustainable citrus production system (El-Otmani et al., 2002), thus encouraging vegetative growth. A significant increase in shoot length of different citrus species by urea sprays was also reported by (Dubey et al., 2003). Moreover, the increase in vegetative growth by the 2, 4-D sprays might be in accordance to that 2,4-D is a synthetic auxin known to stimulate cell enlargement and stem growth (Davies, 1995).

The mentioned results are in harmony with those obtained for fruit retention in the present study Similarly, Nimaljit-Kaur et al. (2000) stated that the highest fruit drop control was exhibited by spraying 2, 4-D at 20 ppm after fruit set The auxin application might decrease the response of fruit abscission zone to ethylene, thus preventing fruits from dropping (Davies, 1995) as well as it maintain the cells at zone of abscission, preventing the synthesis of hydrolytic enzymes such as cellulose which decompose the cell wall (Zur and Goren, 1977; Modise et al., 2009). In addition, urea is known to encourage the vegetative growth (as mentioned before in this study), thus, increasing photosynthesis efficiency and the accumulation of carbohydrates needed for fruit growth preventing it from abscission Boron stimulates the transport of sugars throughout the plant and affects auxin metabolism which is necessary for fruit growth (Lovah, 1985), it has also been reported to encourage the uptake and mobility of calcium (Wojcik, 1998). In addition, the increase in fruit retention by calcium compounds sprays obtained in this study may be according to increasing calcium and insoluble pectin contents of

these fruits as reported by (Byungwoo and Seung, 1999).

In the present study, an increase in yield by the previous treatments might be due to an increase in fruit retention and a decrease in fruit drop by the same treatments obtained. A similar increase in citrus fruit tree yield was reported by urea sprays (Rathore and Chandra, 2003; El-Otmani et al., 2002), boron sprays (Sajida-Perveen and Rehman, 2000) and by 2, 4-D sprays (Nirmaljit-Kaur et al., 2000 and Babu and Yadav, 2002) Also, Sharma et al. (2000) reported that calcium chloride sprays at 0.5% increased the yield of lemon tree.

Conclusions

Orange trees (*Citrus sinensis* L.) behave differently to different agrochemicals foliar sprays treatments and physiological stages. At pea or marble stage urea or 2,4-D alone significantly increased vegetative growth. At the pea stage the boric acid or 2,4-D alone increased final fruit retention and decreased pre-harvest fruit drop. At the marble stage calcium superphosphate alone increased final fruit retention and decreased pre-harvest fruit drop. At pea or marble stage 2,4-D foliar sprays alone or with the different calcium compounds significantly increased fruit retention and decreased fruit drop after June drop.

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