ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 45(4): 1581-1590, .(2007).

EFFECT OF ROOTSTOCKS, FRUIT POSITION ON TREE CANOPY AND ETHEPHON DIPPING TREATMENT ON DEGREENING AND QUALITY OF VALENCIA ORANGES

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ABSTRACT

This work was carried out during two successive seasons (2004 and 2005) to study the effect of rootstock, fruit position on tree canopy and ethephon fruit dipping treatments on Valencia orange fruit degreening and fruit quality. Sour orange rootstock improved the fruit peel color especially at the northern position of the tree canopy, however Volkamer lemon rootstock significantly increased SSC: acid ratio. Lowest weight loss percentage and highest ascorbic acid content were obtained by 2000 ppm ethephon treatment in fruit of southern position of tree canopy grafted on volkamer lemon rootstock. Fruit picked from southern position of tree canopy grafted on volkamer lemon rootstock showed higher respiration rate than other fruit. Ethephon treatment improved the fruit peel color and fruit tends to be orange colored.

Keywords: rootstock, fruit position, ethephon, postharvest treatment, degreening, fruit quality, fruit respiration, Valencia oranges.

INTRODUCTION

Valencia oranges (*Citrus sinensis*) are one of the popular fruit in Egypt and world. The marketing window is start in March in Egypt. Citrus Fruit quality was markedly influenced by rootstock (Faguet and Blanco, 2000 & Takahara *et al.*, 2001) and fruit position on the tree (Shu, 2002 & Freemand and Robbertse, 2003). The external appearance of citrus is used by the consumer as an indication of quality. Degreening is thus becoming an important commercial aspect in the preparation of citrus for the consumer. The external color of citrus fruits is more often related to climatic conditions than to internal maturity. Rind color of citrus fruit is largely determined by prevailing weather conditions during fruit maturation. Two temperature effects on rind color of citrus fruit are important, namely, the requirement for optimum temperature favoring biochemical processes affecting chlorophyll degradation and carotenoid biosynthesis, and the effect of temperature on the entire tree which influences hormone levels in the fruit via the roots (Goldschmidt, 1988). Many cultivars still have an external appearance of immaturity with a green peel, but are in fact internally mature. Citrus fruit are non-climacteric due to the virtual absence of an increase in ethylene production and respiration rate during ripening (Kader, 1992). Despite citrus fruit producing minute amounts of ethylene during ripening, exogenous application of the gas accelerated physiological and molecular responses similar to those naturally induced during ripening (Goldschmidt *et al.*, 1993; Alonso *et al*, 1995 and Porat *et al.*, 1999). Therefore, the involvement of ethylene in the ripening of citrus fruit may depend on changes in the sensitivity of the tissue to the hormone (Alonso *et al.*, 1995). One of the most remarkable effects of ethylene on citrus fruit quality is the enhancement of peel color change. This treatment is commercially used worldwide to promote peel degreening in many citrus species, especially in early season fruit in which the pulp reaches maturity and becomes edible when the peel is still green, and also to achieve uniform external color (Saltveit, 1999). Ethylene-induced peel degreening is the result of both a co-ordinated degradation of chlorophylls (Huybrechts *et al.*, 2003; Kim *et al.*, 2004 and Eshghi and Tafazoli, 2007) and promoting carotnoid biosynthesis (El-Rayes, 2000 & Rufini *et al.*, 2004). The effect of exogenous ethylene on the mechanisms leading to chlorophyll breakdown in the flavedo of citrus fruit has received considerable attention. This treatment is only cosmetic and does not alter the flavor of the fruit. The liquid treatment is currently available. The source of ethylene is the chemical [(2-chloroethyl) phosphoric], which is liquid ethylene-releasing compound with the chemical name ethephon. Ethephon induced color change in peel and advanced fruit maturation (El-Rayes, 2000; Agusti *et al.*, 2002 and Alferez *et al.*, 2006).

The object of this study was to evaluate the effect of rootstock, fruit position on the tree canopy and fruit dipping ethephon treatment on Valencia orange fruit quality to supply the market with the consumer requirement from Valencia orange fruit, in January, two months earlier than marketing window in March.

MATERIALS AND METHODS

This work was carried out during two successive seasons (2004 and 2005), respectively at Sakha farm, Kafer El-Shekh Governorate. Fruits of Valencia oranges were picked in January 15th in both studied seasons, from three separated positions (north, south and inner sites) on the trees canopy (11 years old), grafted on two different rootstocks i.e., sour orange and volkamer lemon. Fruits were uniform in size and free of any peel defect. The harvested fruits were divided to sex groups (2 rootstocks x 3 positions) and transferred to the Hort. Dept. Fac. of Agric. Kafer El-Shekh Univ. within one hour at ambient temperature (22 °C). The fruits were drenched with 500 ppm thiabendazol (TBZ) solution and completely air dried. Each fruits group was divided to three subgroups, and each subgroup was subjected to dipping in either water (control), 1000 or 2000 ppm ethephon solutions for 10 min for each. The treated fruits were completely air dried and stored at ambient temperature (22 ± 2 °C and 80-85 RH) for seven days as a shelf life. Each treatment was represented by three replications with 20 fruits for each.

The stored out fruits, after shelf life, were represented for visual assessment and chemical analysis. The peel color for the stored out fruits was visually assessed according to color chart. The color categories are given a score 1, 2, 3, 4, 5 and 6 which correspond to a rating green, yellowish green, greenish yellow, yellow, orange yellow and orange, respectively. Weight loss was calculated and expressed as a percentage in relation to the weight before treatment.

Evaluation of CO_2 from fruit was determined by sealing five fruits from every treatment for each replicate in 2 liters jar at ambient temperature (22 ± 2 °C & 80-85 RH). Headspace gasses were withdrawn for 1 h in KOH solution (0.1N). CO_2 production was calculated as mg $kg^{-1}h^{-1}$ using titration method as described by EL-Shemy and EL-Morsy (2001).

The juice sample of five fruits for every treatment of each replicate was analyzed to determine the following: soluble solid content (SSC), titratable acidity (TA) (% citric acid) and ascorbic acid content (mg/100 ml juice) by the official methods (A.O.A.C, 1980).

Five fruits for every treatment of each replicate were juiced for juice volume and sensory quality evaluation was determined by seven untrained panelists. Sweetness, acidity and flavor were rated using a scale rating from 1 to 9 according to the intensity of the attributes.

The experiment was designed as factorial arrangement of treatments in a randomized complete block design according to Byrkit (1987), whereas factorial completely randomized arrangement was used for sensory evaluation. Data in percentage were transformed to the arcsine of the square root. Means were separated by Duncan's multiple range test at 5 % level of significance.

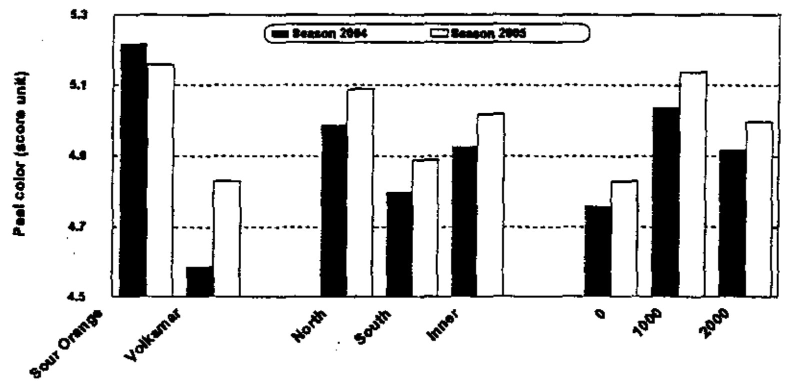
RESULTS AND DISCUSSION

Comparison of fruits at the harvest time, before the treatments, is shown in Fig. (1). Differences in fruit peel color can be seen in rootstocks and fruit positions on the tree canopy. The fruit was more colored on sour orange rootstock especially at the northern position of the tree canopy. After the treatment of ethephon, at both concentrations, significantly improvement in the fruit peel color was achieved and the fruit tends to be orange color compared to the controlled fruit which was orange yellow colored. The obtained results are in harmony with the previous studies (Agusti *et al.*, 2002; Singh *et al.*, 2002 and Alferez *et al.*, 2006) and might due to that ethephon treatment increased ethylene production (Huybrechts *et al.*, 2003 and Suresh and Zora, 2003), stimulated progressive loss of chlorophyll and gain of carotenoids (El-Rayes, 2000, Huybrechts *et al.*, 2003 and Alferez *et al.*, 2006) and hastened fruit maturity (Kim *et al.*, 2004).

After shelf life (Fig. 2), fruit grafted on volkamer lemon root stock showed lower weight loss (2.61 & 2.72 %) than sour orange (2.64 & 2.86 %). Also, fruit on southern position of tree canopy showed the lowest weight loss (2.59 & 2.41 %) compared with fruits on other position on tree canopy. Fruit treated by 2000 ppm ethephon showed the lowest weight loss comparing by the other treatments.

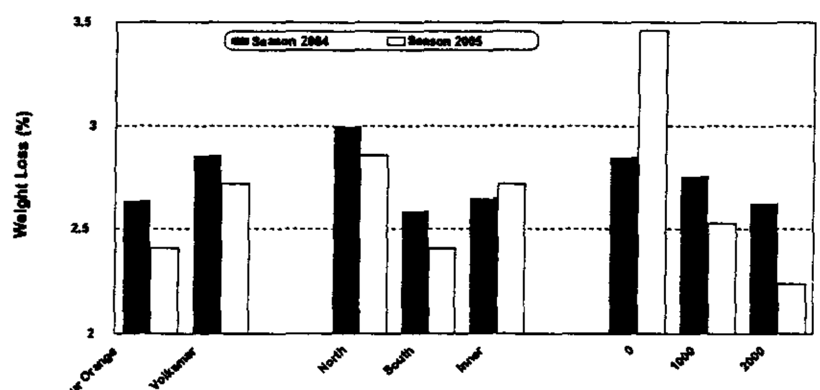
Data in Table (1) show that the fruit chemical properties were markedly affected by rootstocks and fruit position on the tree canopy. Volkamer lemon rootstock significantly decreased SSC and titratable acidity but increased SSC: acid ratio compared to sour orange rootstock in the both seasons. Fruit chemical properties showed different affect with the fruit position on the tree canopy in the both seasons.

After shelf life, fruit picked from tree grafted on volkamar lemon showed significantly decrease in SSC and titrarable acidity contents, whereas SSC: acid ratio showed different affect compared to those picked from tree grafted on sour orange rootstock in the both seasons. Previous studies showed that fruit chemical parameters were significantly affected by rootstock (Foguet and Blanco 2000 & Takahara *et al.*, 2001) and fruit position on tree canopy (Shu, 2002 and Freeman & Robbertse, 2003). Ethephon had no significant effect on the fruit chemical properties. Rahmi and Najouyan (1997) showed that ethephon had no clear effect on the chemical properties of lime fruits whereas, Singh *et al.*, 2002 on apples and Zora and Janes, 2001 on mangoes showed that chemical prosperities were significantly affected with ethephon application. This result might due to that mangoes and apples are climacteric fruit whereas Valencia oranges are non climacteric.



Rootstock **Fruit position** **Ethephon (ppm)**

Fig.(1): Effect of rootstock, fruit position on tree canopy and dipping ethephon treatment on Valencia orange fruit peel color (4=yellow, 5=orange yellow, 6=orange).



Rootstock **Fruit position** **Ethephon (ppm)**

Fig.(2): Effect of rootstock, fruit position on tree canopy and dipping ethephon treatment on Valencia oranges weight loss percentage.

Table (1): Effect of rootstock, fruit position on tree canopy and ethephon dipping treatment on Valencia orange fruit chemical properties during 2004 and 2005 seasons

Factors and treatments	SSC (%)		Acidity (%)		SSC/acid	
	2004	2005	2004	2005	2004	2005
Before treatments						
Rootstock (R)						
Sour orange	12.20	12.67	1.80	1.83	6.77	6.74
Volkamer	11.71	12.09	1.63	1.80	7.21	6.90
F test	**	**	**	NS	**	*
Position (P)						
North	11.87 b	12.23 a	1.69 a	1.83 a	7.01 a	6.81 a
South	12.10 a	12.47 a	1.72 a	1.81 a	7.06 a	6.79 a
Inner	11.90 b	12.43 a	1.71 a	1.82 a	7.91 a	6.86 a
R x P	**	*	**	*	*	**
After treatments						
Rootstock (R)						
Sour orange	11.92	12.30	1.10	1.02	10.91	12.09
Volkamer	11.82	11.13	1.03	0.95	11.62	11.77
F test	**	**	**	**	**	**
Position (P)						
North	11.81 c	11.48 c	1.06 b	1.05 a	11.24 b	10.74 c
South	11.87 b	12.11 a	1.09 a	0.96 b	11.03 c	12.14 b
Inner	11.94 a	11.57 b	1.04 b	0.92 c	11.52 a	12.48 a
Ethephon (E)						
Control	12.19 a	12.01 a	1.08 a	1.01 a	11.42 a	11.87 b
1000 ppm	11.72 b	11.64 b	1.03 b	0.96 b	11.47 a	12.13 a
2000 ppm	11.71 b	11.50 c	1.09 a	0.98 ab	10.91 b	11.79 b
R x P	**	**	**	NS	**	**
R x E	**	**	**	**	**	**
P x E	**	**	**	**	**	**
R x P x E	**	**	**	**	**	**

In the same cell, means followed by the same letter are not significantly different at the level of 5 % according to DMRT.

At the harvest time, before the treatments, the highest ascorbic acid content (Table, 2) was obtained in fruit picked from tree grafted on sour orange rootstock, and also in the fruit of southern position of the tree canopy comparing with volkamer lemon rootstock and other positions of the tree canopy. However, after shelf life, higher ascorbic acid content was obtained in fruit picked from tree grafted on volkamer lemon root stock and fruits on southern position of tree canopy also.

Juice volume (Table, 2) shows no significantly different with rootstock or ethylene treatment and showed no clear effect with fruit position on the tree canopy.

Table (2): Effect of rootstock, fruit position on tree canopy and ethephon dipping treatment on juice volume, ascorbic acid and respiration rate of Valencia orange fruit during 2004 and 2005 seasons

Factors and treatments	Juice volume (%)		Ascorbic acid (mg/100ml juice)		CO_2 (mg $kg^{-1}h^{-1}$)	
	2004	2005	2004	2005	2004	2005
Before treatments						
Rootstock (R)						
Sour orange	52.39	45.95	66.06	62.21	0.81	0.89
Volkamer	52.56	48.35	61.92	61.19	0.77	0.72
F test	NS	NS	**	NS	NS	**
Position (P)						
North	51.92 b	47.04 a	61.54 c	60.32b	1.06 a	1.05 a
South	51.83 c	47.08 a	66.64 a	63.41 a	0.55 c	0.67 b
Inner	53.67 a	47.33 a	63.79 b	61.36b	0.76 b	0.70 b
R x P	**	NS	**	**	*	**
After treatments						
Rootstock (R)						
Sour orange	56.76	50.75	65.20	64.52	0.97	0.89
Volkamer	56.54	50.76	65.66	66.52	1.08	0.94
F test	NS	NS	NS	**	**	**
Position (P)						
North	55.91 a	52.40 a	64.41 b	65.73 b	0.92 b	0.90 b
South	56.43 a	50.11 ab	70.38 a	67.81 a	1.24 a	1.06 a
Inner	57.60 a	49.75 b	61.50 c	63.02 c	0.92 b	0.78 c
Ethephon (E)						
Control	56.37 a	51.76 a	66.38 a	66.22 a	0.92 b	0.60 c
1000 ppm	56.82 a	49.48 a	65.19 a	64.40 b	1.18 a	1.25 a
2000 ppm	56.75 a	51.02 a	64.72 a	65.93 a	0.98 b	0.90 b
R x P	NS	NS	**	**	**	NS
R x E	NS	NS	**	**	**	**
P x E	NS	NS	**	**	**	**
R x P x E	NS	NS	**	**	**	**

In the same cell, means followed by the same letter are not significantly different at the level of 5 % according to DMRT.

Before ethephon treatment, a decrease in fruit respiration (Table, 2) was achieved in the fruit picked from tree grafted on volkamer lemon rootstock (0.77 & 0.72 CO_2 mg $kg^{-1}h^{-1}$) compared to the fruit picked from tree grafted on sour orange rootstock (0.81 & 0.89 CO_2 mg $kg^{-1}h^{-1}$) in the two seasons, respectively. Fruit of the northern position showed 1.93 and 1.56 fold respiration compared to the fruit of the southern position of the tree canopy in the two seasons, respectively. After shelf life, fruit picked from tree grafted on volkamer lemon showed significantly higher respiration (1.08 & 0.94 CO_2 mg $kg^{-1}h^{-1}$) compared to sour orange rootstock (0.97 & 0.89 CO_2 mg $kg^{-1}h^{-1}$) in the two seasons, respectively. Fruit picked from the southern position of the tree canopy was significantly higher respired than the other positions. The ethephon treatment, especially at 1000 ppm, significantly increased fruit respiration (1.18 & 1.25 CO_2 mg $kg^{-1}h^{-1}$) compared to the control treatment (0.92 & 0.60 CO_2 mg $kg^{-1}h^{-1}$) in the two seasons, respectively. In this sphere, similar results were obtained by Tatsumi (2000) on hebezu; Feng *et al.*, (2003) on kiwi and Suresh and Zora, (2003) on mango and showed that ethephon treatment enhanced fruit respiration.

The obtained data (Table, 3) revealed that none of the treatments, rootstocks, fruit position on the tree canopy and ethephon treatment had significantly effect on the sensory attributes, especially in the second season. In contrast, sensory values were affected by ethephon treatment on mangoes (Centurion *et al.*, 1998) and apples (Drake *et al.*, 2005) and this might due to that mangoes and apples are climacteric fruits whereas Valencia oranges are non climacteric fruit.

Table (3): Effect of rootstock, fruit position on tree canopy and ethephon dipping treatment on sensory evaluation of Valencia orange fresh juice during 2004 and 2005 seasons

Factors and treatments	Juice acidity (1-9)		Juice sweetness (1-9)		Juice flavor (1-9)	
	2004	2005	2004	2005	2004	2005
Before treatments						
Rootstock(R)						
Sour orange	5.34	6.44	5.16	5.89	5.61	6.89
Volkamer	4.66	6.00	4.97	6.56	5.54	7.33
F test	**	NS	**	NS	NS	NS
Position (P)						
North	5.06 a	6.33 a	5.01 b	6.17 a	5.63 a	6.83 a
South	5.00 a	6.33 a	4.83 b	6.50 a	5.40 a	7.67 a
Inner	4.00 a	6.00 a	5.35 a	6.00 a	5.70 a	6.83 a
R x P	**	NS	**	NS	*	NS
After treatments						
Rootstock (R)						
Sour orange	5.48	5.41	5.26	5.30	5.85	5.81
Volkamar	5.78	5.78	5.07	5.15	6.15	6.19
F test	NS	NS	NS	NS	NS	NS
Position (P)						
North	6.06 a	6.00 a	5.11 ab	5.17 a	6.33 a	6.33a
South	5.28 a	5.33 a	5.67 a	5.67 a	6.06 ab	6.00 a
Inner	5.56 a	5.44 a	4.72 b	4.83 a	5.61 b	5.67 a
Ethephon (E)						
Control	6.06 a	5.94 a	4.94 a	5.06 a	6.00 a	6.06 a
1000 ppm	5.22 a	5.39 a	5.50 a	5.39 a	6.06 a	5.94 a
2000 ppm	5.61 a	5.44 a	5.06 a	5.22 a	5.94 a	6.00 a
R x P	NS	NS	NS	NS	NS	NS
R x E	NS	NS	NS	NS	NS	NS
P x E	NS	NS	NS	NS	NS	NS
R x P x E	NS	NS	NS	NS	NS	NS

In the same cell, means followed by the same letter are not significantly different at the level of 5 % according to DMRT. Sweetness, acidity and flavor were rated using a scale rating from 1 to 9 according to the intensity of the attributes.

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تأثير الأصل وموقع الثمار على الأشجار والمعاملة بالإثيفون على ازالة اللون الأخضر وجودة ثمار البرتقال الفالنشيا

أسامة كمال العباسي
قسم البساتين- كلية الزراعة- جامعة طنطا

أجريت هذه التجربة خلال موسمي ٢٠٠٤ & ٢٠٠٥ وذلك لدراسة تأثير كل من الأصل وموقع الثمارعلى الأشجار و معاملة غمس الثمار في محلول الإثيفون وذلك على ازالة اللون الأخضر وكذلك جودة ثمار البرتقال الفالنشيا. وقد أظهرت الدراسة أن أصل النارنج قد حسن من لون قشرة الثمار وخاصاً ثمار الجزء الشمالي للشجرة بينما قد أظهر أصل فولكا ماريان زيادة معنوية في النسبة بين المواد الصلبة الذائبة الكلية : الحموضة. وقد وجد ان معاملة الغمس بالاسيفون بتركيز ٢٠٠٠ جزء في المليون قد أعطت اقل نسبة مئوية للفقد في الوزن واعلى محتوى من حمض الاسقوربيك وذلك في ثمار الجزء الشمالي للاشجار المطعمة على اصل فولكاماريانا. كما اظهرت ثمار البرتقال فالنشيا للجزء الجنوبي للاشجار المطعمة على اصل فولكامارياما معدل تنفس أعلى من الثمار الأخرى. كما أدت معاملة الغمس في الإثيفون الى تحسين لون قشرة الثمار والتي اظهرت لوناً برتقالياً.