Degreening Enhancement of Washington Navel Orange Fruits With Ethephon

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Abstract: Ethephon as preharvest–sprying (at 0, 150, 200, 300, 400 and 500 ppm) and as postharvest–dipping (at 0, 200, 300, 400, 500, 1000, 1500 and 2000 ppm) were applied to Washington Navel orange, respectively during 2004 and 2005 seasons. Spraying ethephon at 400 ppm advanced harvesting date by about 10 days and greatly reduced fruit and leaf abscission especially 20 days after treatment. Either pre or postharvest applications of ethephon increased markedly degreening score, carotenoid content, as well as SSC% and SSC/acid ratio, while it reduced chlorophyll (a, b) and juice acidity. However, ethephon treatments involved in loss of chlorophyll (a, b) and development of carotenoids which associated with colour improvement correspondly with increasing ethephon concentration. Fruits stored for 15 days had higher degreening score, carotenoids and SSC, while they had lower chlorophyll and acidity than fruits stored for 5 days. Fruit weight loss was the least in fruits dipped in ethephon at 1500 ppm and stored for 15 days.

Keywords: degreening, ethephon, preharvest, postharvest, orange-citrus, chlorophyll, carotenoid, storage.

INTRODUCTION

Citrus production is very important for Egypt in terms of both domestic consumption and exports. In 2004, the citrus fruit production was about 20887.599 tons from which about 695.383 tons were exported (Ministry of foreign trade and industry, 2005). Degreened orange fruit is a substantial factor in the economic of citrus industry since its plays an important role in extending the marketing windows and reduction in the competition with the other exporting countries. In addition, an advance in their commercialization represents important returns. The rate of degreening of citrus fruits can be increased by using any ethylene-releasing compound (e.g. ethephon or ethrel) which have been used commercially to enhance earliness and improve colour of citrus through the destruction of chlorophyll and promoting carotenoids biosynthesis (Rath and Pattnaik, 1989; Torreblanca *et al.*, 1989; Hearn, 1990; Pons *et al.*, 1994; Roux *et al.*, 1997; Yamauchi *et al.*, 1997 and El – Rayes, 2000). Ethephon treatments increased markedly peel colour, carotenoids content, as well as SSC and SSC/acid ratio. In addition, it reduced chlorophyll content and juice acidity (Purandare *et al.*, 1992; Yamauchi *et al.*, 1992; Gullu and Agar, 2000 and El-Rayes, 2000).

This study aimed to know which method is better for applications of ethephon, preharvest or postharvest for degreening of Washington Navel orange, in addition to which concentration is more effective to be used.

MATERIALS AND METHODS

Experiments were conducted for two successive seasons (2004 and 2005) to study the effect of preharvest–spraying (Exp.1) and postharvest-dipping (Exp.2) of ethephon on the fruit degreening acceleration of Washington Navel orange (*Citrus sinensis* L.). The trees were 18–year–old, grafted on sour orange, grown at 3x7 m apart in sandy soil under drip irrigation system at Wady Al-Mollak region, Ismailia, Governorate. Trees received similar cultural practiced during the investigation.

Twenty four trees of Washington Navel orange, as for as possible, healthy and uniform size were chosen for this study.

Exp. (1): Effect of preharvest– spraying of ethephon on degreening:

The trees were sprayed at colour break (25^{th} of Oct. in the first season and 29^{th} of Oct. in the second one) by different concentrations (0, 150, 200, 300, 400 and 500 ppm) of ethephon containing the surfactant agent Triton (0.1 %) and calcium acetate (1%) to reduce leaf and fruit abscission according to Pons *et al.* (1994).

The experiment included six treatments, replicated four times with a single tree for each and arranged in a randomized complete blocks design.

Abscised leaves were collected at 10 day intervals under each tree, then the collected leaves were weighed and sample of 25 leaves was also weighed. So, the number of abscised leaves was calculated as the following equation: Number of leaves= (25 x total leaves weight)/weight of 25 leaves. Dropped fruits under each tree were counted at 10–day intervals, then the percentage of abscised levees and fruits were calculated as compared with the control. At the beginning of the experiment (zero time), and after 10 days from treatment, five fruits from each replicate were taken for determination of physical and chemical properties.

Degreening score of fruits were assessed using a subjective scale of 1 to 10 (1= green, 3= green – yellow, 5= yellow– green, 7= yellow, 9= yellow – orange, 10= orange). Degreening score was calculated according to the following formula, degreening score= $\sum$ (number of fruit in each category X the scale number given) / number of fruit in sample, as described by Gullu and Agar (2000).

Chlorophyll "a, b" and carotenoids were determined in fruit peel, after extraction with 80 % acetone, using spectrocolourmeter according to Lichenthaler and Wellburn (1983). Soluble solids content % (SSC %) was determined by using Carl–Zeiss hand refractometer. Titratable acidity % was determined as citric acid according to A.O.A.C. (1996) and SSC/acid ratio was estimated.

Exp. (2): Effect of postharvest application of ethephon on degreening during storage:

Mature fruits at colour break were harvested (according to Isshak *et al*,.1978) from the same trees and time as in the first Experiment. Fruits were selected for uniform colour and size, free from surface injury and peel disorders. Fruits were transported immediately to the postharvest laboratory, and then washed by chlorine solution (100 ppm). They were dipped for five min. in solutions containing different concentrations (0, 200, 300, 400, 500, 1000, 1500 and 2000 ppm) of ethephon and a surfactant Triton 0.1 %. Treated fruits were air–dried, put in perforated colourless plastic (36 X 24 cm) bags. All bags from each treatment were stored in cardboard boxes at room temperature (25 ± 2 C° and 75 – 85 RH). Each box contained 15 fruits formed a treatment unit and was replicated four times (4 boxes for each treatment). So, the experiment was arranged in a completely randomized block design with a factorial arrangement of storage duration. Five fruits from each replicate were taken at 5–day intervals for determination of physical and chemical properties.

Fruit weight loss during storage was calculated from the difference between the initial and final weight (g) of stored fruits, and expressed as percentage of weight loss. In addition, parameters which include degreening score, soluble solids content, titratable acidity, chlorophyll "a , b" and carotenoids were determined as described in exp. (1).

Statistical analysis:

The experimental design was randomize complete blocks in exp. (1) and randomize complete blocks with a factorial arrangement of storage duration in exp. (2) (Steel and Torrie, 1980). Analysis of variance and means comparison (LSD at 5 %) were performed using MSTAT-C program version 7 (M- STAT, 1990).

RESULTS

Exp. (1): Effect of preharvest application of ethephon:

Degreening score increased gradually from 9.0 to 9.5 and 9.8 % in the first season and from 8.3 to 9.1 and 9.9 % in the second one when the rate of ethephon was increased from 300 to 400 and 500 ppm, respectively (Table 1). There was no significant difference among the three considered treatments. It could be observed that orange colour development was faster in fruit treated with ethephon than untreated, which stayed to light green colour (Photo 1). Preharvest application of ethephon induced reduction in chlorophyll (a, b), where sharp reduction effect was noted in both seasons particularly with 300, 400 and 500 ppm, although the differences failed to attain significant. As for carotenoids, an opposite trend was resulted where a significant increment in carotenoids was induced as the concentrations of ethephon were increased. It could be seen that the colour measurements determined reflect changes in both photosynthetic pigments which corresponded with increasing the concentration of ethephon.

Ethephon at rates 300, 400 and 500 ppm induced high significant fruit drop, while 2.1 and 1.5 % fruit drop occurred with 150 ppm at 20 days after treatment, in the first and second seasons, respectively (Table 1). Leaf abscission was significantly increased as the concentration of ethephon increased. At 20 days after treatment, leaf abscission was also greatly reduced in all concentrations and in both seasons.

A gradual increase in SSC had generally taken place as the concentration of ethephon was increased. A close trend was obtained in the second season, where the most striking effect was linked to high concentration. As concern the acidity, in the two seasons insignificant reductive effects were attached to 300, 400 and 500 ppm concentrations, while a rather low effect was attributed to 150 ppm concentration.

Exp. (2): Effect of postharvest application of ethephon:

Ethephon as postharvest application induced significant reduction in weight loss, where minimum weight loss was obtained from the rate of 2000 ppm in both seasons (Table, 2). During storage period fruits weight loss significantly increased, so the highest weight loss was obtained from the fruits stored up to 15 days. There was a significant interaction between concentration of ethephon and storage duration, so that fruits weight loss increased during storage elongation under all the concentrations of ethephon.

Ethephon applied as postharvest dipping at rate of 1500 or 2000 induced higher significant degreening score than untreated fruits as shown in Table 2 and Photo (2, A & B).

Colour development increased with increasing ethephon concentration. Degreening score was significantly affected by storage period. Thus, during the storage period up to 5–15 days, colour developed from green – yellow to yellow as shown in Photo (2, A & B). The interaction showed significant effect on degreening score where the highest degreening score was obtained by the highest level of ethephon after 15 days storage. However, the lowest degreening score under each ethephon level was obtained after 5 days storage.

Chlorophyll "a" and "b" behaved in similar manner where they gradually and significantly decreased as the concentration of ethephon increased (Table 3). The highest chlorophylls content was observed in control fruits; whereas the lowest chlorophylls content was recorded in fruits received 2000 ppm in both seasons. However, for the storage period, chlorophylls gradually decreased within the storage period and the lowest chlorophylls were found after 15 days. There was a significant interaction between concentrations of ethephon and storage duration, since the lowest chlorophylls content at higher ethephon concentration were detected at the end of storage period.

Ethephon at rates of 1000, 1500 and 2000 ppm increased carotenoids level, where fruit was already degreened; and 200 and 300 ppm were less effective compared to other treatment (Photo 2, A). Storage duration was significantly effected on carotenoids, which increased by prolonging storage time and associated with degreening changes in the fruits (Photo

2, B). The carotenoids content were significantly affected by the interaction, so the highest value of carotenoids was obtained when fruits treated with 2000 ppm and stored for 15 days (Table 3).

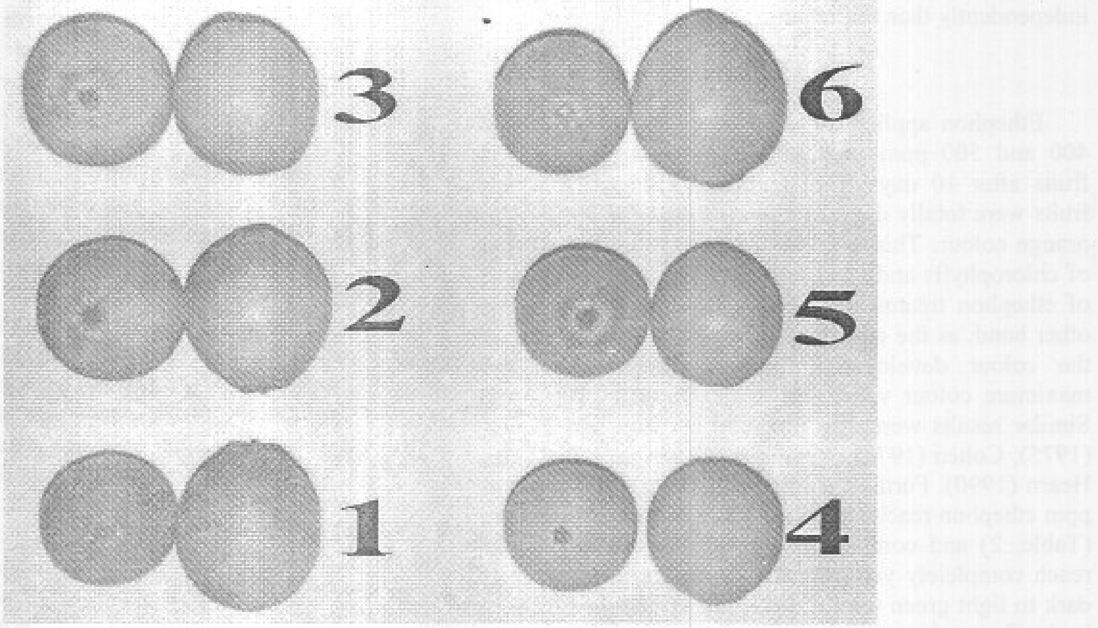
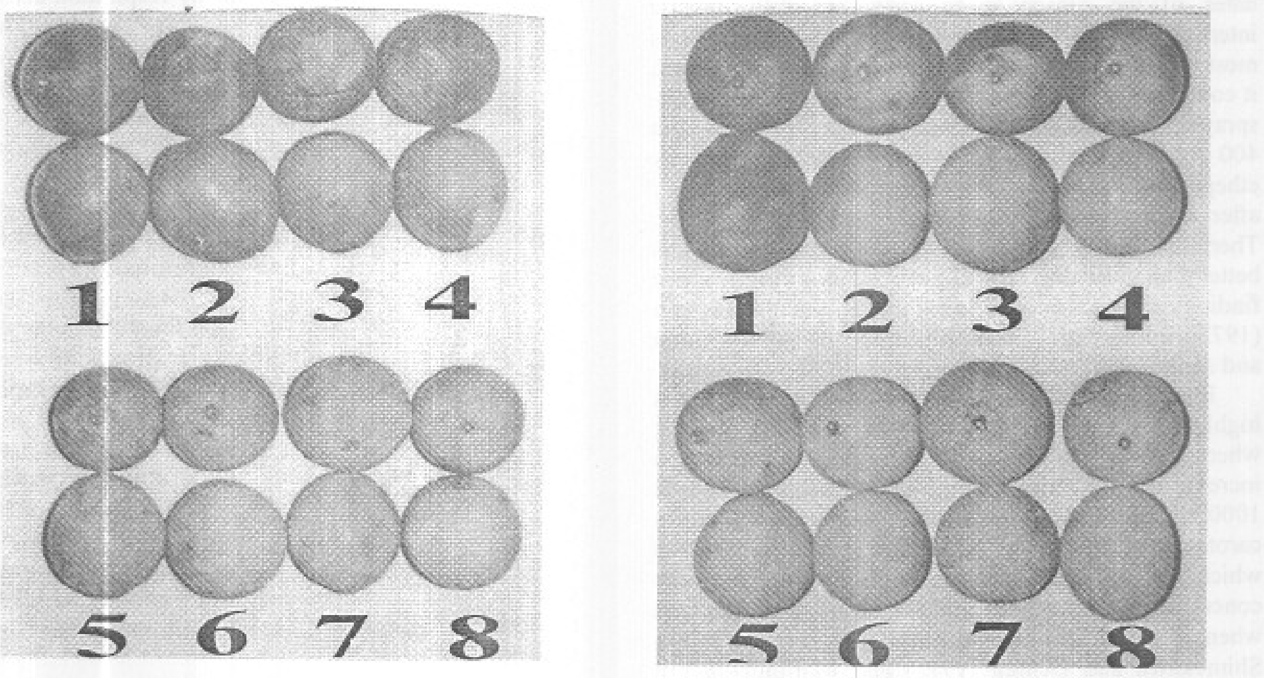


Photo (1): Colour responses of Washington Navel orange to preharvest ethephon treatments at various concentrations (1= control, 2= 150, 3= 200, 4= 300, 5= 400 and 6= 500 ppm). Fruit photographed after 10 days from treatment.



(A) (B)

Photo (2): Colour responses of Washington Navel orange to postharvest ethephon treatments at various concentrations (1= control, 2= 200, 3= 300, 4= 400, 5= 500, 6= 1000, 7= 1500, 8= 2000 ppm). Fruit photographed, A= after 10 days storage, B= after 15 days storage.

Slight differences in soluble solids content (SSC) were revealed as a result of using different concentrations of ethephon (Table 4). SSC was only significantly increased in the second season. Although the increment in SSC was recorded from fruits with 1500 or 2000 ppm, with no significant differences between them. SSC was significantly increased by extending storage duration and the highest value was after 15 days in two seasons.

Titratable acidity in fruit juice decreased with an increase in the concentrations of ethephon where the lowest acidity was recorded with 2000 ppm compared to the other concentrations. A significant reduction in acidity was also detected at the end of storage period (Table, 4). SSC/acid ratio showed similar trend like that of SSC. The interaction between ethephon concentration and storage period was not significant for SSC, acidity and SSC/acid ratio. The insignificant effects of the interaction means that each factor behaved independently than the other.

DISCUSSION

Ethephon applied as preharvest spraying at rats of 400 and 500 ppm induced significant degreening of fruits after 10 days from treatment (Photo 1), where fruits were totally degreened on the tree and reached an orange colour. This is probably due to the degradation of chlorophylls and synthesis of carotenoids as a result of ethephon treatment (Trebitsh *et al.,* 1993). On the other hand, as the ethephon–dipping rate was increased the colour development was increased which the maximum colour value was achieved with 2000 ppm. Similar results were also obtained by Jahn and Young (1975); Cohen (1978); Ahrens and Barmore (1988) and Hearn (1990). Further, fruits treated with 1500 or 2000 ppm ethephon reached yellow–green colour after 5 days (Table, 2) and continued to develop until 15 days to reach completely yellow, while control fruits remained dark to light green with score value of 1.63 and 1.66 % in the first and second seasons, respectively. The above results mean that ethephon could be used as a step in the packing house operation especially during the early dates of the season when fruits are fully mature internally but peel still green and improved colour is most desirable for export or domestic market. However, it could be observed that fruits degreened by ethephon–spraying reached an orange colour after 10 days with 400 or 500 ppm (Photo 1), whereas those degreened by ethephon–dipping attained only a pale yellow colour after 15 days with 1500 or 2000 ppm (Photo 2 – B). Therefore, fruits degreened by ethephon–spraying is better than those degreened by ethephon–dipping. These findings are in harmony with those of Young and Jahn (1972); Pons *et al.* (1992); El–Rayes (2000) and Gullu and Agar (2000).

Ethephon application as postharvest dipping had a highly significant effect on photosynthetic pigments; where chlorophyll (a, b) reduced as the concentration increased. In addition, fruits treated by ethephon at 1000, 1500 and 2000 ppm showed increases in carotenoids level associated with degreening changes which was corresponded with increasing the concentration. The same pattern of response was noticed when Ahrens and Barmore (1988); Hearn (1990); Shimokawa and Uchida (1992) and Martinez–Javega (1995), worked on citrus fruits with variable concentrations of ethephon and they found that ethephon treatments caused a significant decrease in chlorophylls content while increased the carotenoids synthesis. This reduction in chlorophylls could be due to that ethephon accelerates the destruction of chlorophylls through enhancement the activity of some enzymes involved in the catabolic processes of chlorophyll which have been identified; for example chlorophyllase (Shimokawa, 1979), chlorophyll oxidase (Holden, 1970) and peroxidase (Shimokawa and Uchida, 1992 and Shimokawa *et al.,* 1990). However, Yamauchi *et al.* (1997) suggested that the acceleration of chlorophyll degradation by ethephon treatment could be due to the enhancement of chlorophllide which is formed by the action of chlorophllase. In the present study, chlorophyll "b" was degraded preferentially over chlorophyll "a" by ethylene treatment (Tables, 1 and 3). Similar results were reported on Satsuma mandarin by Shimokawa (1979). The obtained results in this study indicated that storage duration significantly decreased chlorophylls content and significantly increased carotenoids. Yamauchi *et al.* (1992) likewise found that chlorophyll concentration sharply decreased as storage period increased and fruits gradually turned from green to yellow. They also added that peroxidase and chlorophyllase activity increased during the first 20 days of storage and then decreased. They suggested that chlorophyllase is degraded via a peroxidase pathway.

Application of ethephon as dipping treatments reduced fruits weight loss compared to the control. These trends are in according to the findings of Gupta *et al.* (1983) and Gullu and Agar (2000) who mentioned that ethephon resulted in 8.8 % weight loss compared to 13 % weight loss in conventional degreening by ethylene within the same period. However, fruits weight loss increased significantly by prolonging storage time especially after 15 days. This increment in weight loss may be resulted from the water loss by transpiration and the losses of organic compounds by respiration activity as reported by Martinez–Javega (1995). Moreover, under any ethephon level, fruit weight loss was significantly increased as storage period increased. Similar effect of ethephon on the storage period has been reported by Alfaro *et al.* (1986) and Gullu and Agar (2000).

Ethephon at rate of 500 ppm+ 1 % calcium acetate gave 12.7, 10.4 % of fruit drop and 15.7, 12.9 % of leaf abscission in the first and second seasons, respectively (Table, 1). These results are in harmony with those obtained by Pons *et al.* (1994) who found that ethephon field treatments mixtured with calcium acetate caused 15 % of leaf abscission. Contrary to the previous reports for citrus, Young and Jahn (1972), Torreblanca *et al.* (1989) and Gullu and Agar (2000) found that preharvest application of ethephon (rates above 200 ppm) induced a high percentage of leaf drop (50 to 90 %) and fruit drop (30 to 45 %). In the present trial, the addition of calcium ions to ethephon led to binding pectin substances in the medium layer and consequently reduced the abscission as mentioned by Poovaiah and Leopold (1973).

As the ethephon rate was increased the SSC was slightly increased. Similar response was observed with ethephon–field treatment (Table, 1). These results are in harmony with those of Pons *et al.* (1994) and El–Rayes (2000) who reported that preharvest application of ethephon increased SSC but these results disagreed those of Martinez–Javega (1995) who stated that SSC was maintained without significant changes. These seemingly contradictory results may be attributed to: (1) differences in cultivar and stages of maturity; (2) differences in weather prior to harvest or harvest at different times; (3) differences in the concentration of ethephon used.

The effect of storage duration revealed significant increment in fruits SSC after 15 days. The increase in SSC cloud be due to the degradation of complex insoluble compounds to simple soluble solids. Similar responses have been reported by Purandare *et al.* (1992) who found that TSS % of fruit juice increased during storage.

Either ethephon applied as dipping or as spraying treatments decreased fruit acidity. These results agreed the findings of Pones *et al.* (1994), Martinez–Javega (1995) and El–Rayes (2000) who found that ethylene reduced acidity. As shown in Table (3), fruits stored for 15 days had the lowest acidity. In this respect, citric acid is a respiratory substrate and its consumption in respiration increases with the progress of storage period and this may be responsible for the observed decreases in acidity during the last days of storage.

In conclusion, it could be recommended to spray ethephon at 400 ppm into Washington Navel orange trees to improve fruit colour and advance harvest date by about 10 days. Oppositely, ethephon–dipping at 1500 ppm seemed to be efficient when used during the early period of harvesting.

Table (1): Effect of preharvest application of ethephon on degreening score (%), photosynthetic pigments content, fruit and leaf drop (%), and fruit quality of Washington Navel orange in2004 and 2005 seasons.

Concentration (ppm)	Degreening Score (%)	Chlorophyll (mg / L)		Carotenoids (mg / L)	Fruit drop (%)		Leaf drop (%)		SSC (%)	Acidity (%)	SSC /acid ratio
					Days after treatment						
		a	b		10	20	10	20			
					1st season (2004)						
Control	2.3 ^{d}	4.5 ^{a}	0.89 ^{a}	0.85 ^{d}	0.0 ^{c}	0.0 ^{e}	0.0 ^{e}	0.0 ^{e}	9.7 ^{d}	0.72 ^{a}	13.5 ^{c}
150	7.5 ^{c}	2.6 ^{b}	0.78 ^{a}	1.3 ^{d}	5.3 ^{b}	2.1 ^{d}	4.4 ^{c}	3.4 ^{d}	9.9 ^{cd}	0.69 ^{a}	14.3 ^{c}
200	8.1 ^{bc}	2.0 ^{bc}	0.57 ^{b}	2.6 ^{c}	7.5 ^{b}	4.6 ^{c}	8.2 ^{b}	5.6 ^{c}	10.0 ^{cd}	0.67 ^{ab}	14.9 ^{c}
300	9.0 ^{ab}	1.7 ^{cd}	0.46 ^{bc}	3.0 ^{bc}	9.4 ^{b}	7.3 ^{b}	10.5 ^{b}	7.1 ^{c}	10.6 ^{bc}	0.63 ^{bc}	16.8 ^{b}
400	9.5 ^{a}	1.4 ^{cd}	0.42 ^{bc}	3.8 ^{ab}	10.1 ^{b}	8.2 ^{b}	13.6 ^{a}	9.0 ^{c}	11.0 ^{b}	0.61 ^{c}	18.0 ^{b}
500	9.8 ^{a}	0.91 ^{c}	0.28 ^{c}	4.2 ^{a}	12.7 ^{a}	10.4 ^{a}	15.7 ^{a}	11.9 ^{a}	12.3 ^{a}	0.62 ^{bc}	19.8 ^{a}
					2nd season (2005)						
Control	2.1 ^{d}	3.8 ^{a}	0.78 ^{a}	0.91 ^{c}	0.0 ^{e}	0.0 ^{d}	0.0 ^{e}	0.0 ^{e}	9.4 ^{d}	0.76 ^{a}	12.4 ^{e}
150	6.7 ^{c}	2.5 ^{b}	0.59 ^{b}	1.1 ^{c}	3.1 ^{d}	1.5 ^{c}	3.8 ^{c}	2.3 ^{d}	10.2 ^{c}	0.70 ^{b}	14.6 ^{d}
200	7.4 ^{bc}	1.9 ^{bc}	0.47 ^{bc}	2.3 ^{b}	4.7 ^{cd}	2.5 ^{c}	5.5 ^{c}	4.1 ^{c}	10.7 ^{bc}	0.65 ^{bc}	16.5 ^{c}
300	8.3 ^{abc}	1.3 ^{cd}	0.36 ^{cd}	3.4 ^{ab}	6.5 ^{bc}	4.1 ^{b}	9.4 ^{b}	6.7 ^{b}	11.0 ^{b}	0.61 ^{cd}	18.0 ^{bc}
400	9.1 ^{ab}	0.95 ^{d}	0.31 ^{cd}	3.7 ^{a}	8.3 ^{ab}	5.6 ^{a}	10.1 ^{b}	7.5 ^{b}	11.9 ^{a}	0.60 ^{cd}	19.8 ^{ab}
500	9.9 ^{a}	0.78 ^{d}	0.29 ^{d}	4.5 ^{a}	10.4 ^{a}	6.8 ^{a}	12.9 ^{a}	9.8 ^{a}	12.5 ^{a}	0.58 ^{d}	21.6 ^{a}

Values with the same letter in each column are not significantly different at 5 % level.

Table (2): Effect of post harvest application of ethephon on fruit weight loss (%) and degreening score (%) of Washington Navel orange fruits in 2004 and 2005 seasons.

Concentration (ppm)	Fruit weight loss (%)					Degreening score (%)				
	Storage period (days)				Average (A)	Storage period (days)				Average (A)
	0*	5	10	15		0*	5	10	15	
1st season (2004)										
Control	0.0	6.1	9.4	11.8	6.8^{a}	1.0	1.3	1.7	2.5	1.63^{e}
200	0.0	5.6	9.7	10.4	6.4^{ab}	1.0	2.0	2.3	3.8	2.28^{de}
300	0.0	4.6	8.8	9.9	5.8^{cb}	1.0	2.5	3.3	4.5	2.83^{de}
400	0.0	5.6	7.3	8.7	5.4^{cd}	1.0	3.0	3.7	4.8	3.13^{cde}
500	0.0	4.6	6.9	7.6	4.7^{de}	1.0	3.8	4.3	5.0	3.53^{cd}
1000	0.0	4.2	6.3	6.8	4.3^{e}	1.0	5.5	5.8	6.5	4.70^{bc}
1500	0.0	4.4	5.7	6.9	4.2^{e}	1.0	6.3	7.0	7.3	5.40^{ab}
2000	0.0	4.3	4.7	5.7	3.4^{f}	1.0	7.5	8.5	9.0	6.50^{a}
Average (B)	0.0 D	4.81 C	7.35 B	8.48 A		1.00C	3.99 B	4.58 AB	5.43 A	
2nd season (2005)										
Control	0.0	8.4	8.2	11.1	6.9^{a}	1.0	1.2	1.3	3.1	1.65^{e}
200	0.0	6.5	7.3	9.0	5.7^{cd}	1.0	1.4	3.2	4.2	2.45^{de}
300	0.0	6.5	6.8	10.7	6.0^{bc}	1.0	1.6	3.5	5.1	2.80^{de}
400	0.0	7.3	7.6	9.1	6.0^{bc}	1.0	4.2	4.6	5.5	3.83^{cd}
500	0.0	7.5	6.5	9.4	5.8^{c}	1.0	5.2	6.4	7.6	5.05^{bc}
1000	0.0	6.6	5.9	9.1	5.4^{cd}	1.0	5.2	6.6	7.8	5.15^{abc}
1500	0.0	6.2	6.1	8.0	5.1^{cd}	1.0	6.3	6.8	8.9	5.75^{ab}
2000	0.0	6.0	5.9	6.6	4.6^{e}	1.0	8.4	8.7	9.0	6.78^{a}
Average (B)	0.0 C	6.88 B	6.79 B	9.13 A		1.00 C	4.19 B	4.38 B	6.40 A	

LSD 5% A X B 2004= 1.04 2005 = 1.04 2004 = 1.28 2005 = 1.30

Values with the same small letter in each column or capital letter in each raw are not significantly different at 5 % level.

* zero time.

Table (3): Effect of preharvest application of ethephon on photosynthetic pigments content in flavedo of Washington Navel orange fruits in 2004 and 2005 seasons.

Concentration (ppm)	Chlorophyll a (mg/L)					Chlorophyll b (mg/ L)					Carotenoids (mg/L)				
	Storage period (days)				Average (A)	Storage period (days)				Average (A)	Storage period (days				Average (A)
	0*	5	10	15		0*	5	10	15		0*	5	10	15	
1st season (2004)															
Control	3.9	3.9	3.8	3.7	3.82^{a}	0.8	0.8	0.7	0.7	0.75^{a}	0.6	0.6	0.7	0.8	0.68^{e}
200	3.9	3.7	2.8	2.8	3.30^{b}	0.8	0.7	0.7	0.5	0.68^{ab}	0.6	0.8	0.7	0.9	0.75^{e}
300	3.9	3.6	2.5	2.3	3.08^{bc}	0.8	0.7	0.5	0.4	0.60^{bc}	0.6	0.9	1.0	1.3	0.95^{e}
400	3.9	3.4	2.0	2.0	2.83^{cd}	0.8	0.7	0.6	0.5	0.65^{b}	0.6	1.2	1.6	1.8	1.30^{d}
500	3.9	3.2	2.5	2.1	2.94^{c}	0.8	0.6	0.6	0.4	0.60^{bc}	0.6	1.5	1.9	1.9	1.48^{cd}
1000	3.9	3.1	2.0	0.9	2.48^{de}	0.8	0.6	0.5	0.3	0.55^{cd}	0.6	1.8	2.1	2.4	1.73^{bc}
1500	3.9	3.0	1.9	0.9	2.43^{e}	0.8	0.5	0.4	0.3	0.50^{de}	0.6	1.9	2.3	2.8	1.90^{b}
2000	3.9	3.0	1.7	0.8	2.35^{e}	0.8	0.5	0.3	0.2	0.45^{e}	0.6	2.3	2.5	3.7	2.28^{a}
Average (B)	3.90 A	3.36 A	2.40 B	1.94 B		0.80 A	0.64 B	0.54 B	0.41 C		0.60 C	1.38 B	1.60 AB	1.95 A	
2nd season (2005)															
Control	3.8	3.7	3.7	3.6	3.70^{a}	0.7	0.7	0.6	0.5	0.63^{a}	0.7	0.8	0.9	0.9	0.83^{f}
200	3.8	3.1	2.9	2.8	3.15^{b}	0.7	0.5	0.4	0.4	0.50^{b}	0.7	0.9	1.1	1.4	1.03^{ef}
300	3.8	3.0	2.8	2.0	2.90^{bc}	0.7	0.4	0.3	0.3	0.43^{bc}	0.7	1.3	1.5	1.7	1.30^{de}
400	3.8	3.0	2.5	1.7	2.75^{cd}	0.7	0.4	0.4	0.3	0.45^{bc}	0.7	1.6	1.8	1.9	1.50^{cd}
500	3.8	2.8	2.3	1.6	2.63^{cd}	0.7	0.3	0.3	0.2	0.38^{cd}	0.7	1.8	2.0	2.2	1.68^{bcd}
1000	3.8	2.9	2.0	1.5	2.55^{cde}	0.7	0.3	0.2	0.2	0.35^{de}	0.7	1.9	2.1	2.7	1.85^{bc}
1500	3.8	2.8	1.9	1.0	2.38^{de}	0.7	0.2	0.2	0.2	0.33^{de}	0.7	2.1	2.6	2.9	2.08^{ab}
2000	3.8	2.7	1.4	0.9	2.20^{e}	0.7	0.2	0.2	0.1	0.30^{e}	0.7	2.4	2.8	3.9	2.45^{a}
Average (B)	3.80 A	2.62 B	2.44 BC	1.89 C		0.70 A	0.38 B	0.33 B	0.28 B		0.70 C	1.60 B	1.85 AB	2.20 A	

LSD 5 % A X B 2004 = 0.52 2005= 0.48 2004 = 0.12 2005= 0.09 2004 = 0.44 2005 = 0.36

Values with the same small letter in each column or capital letter in each raw are not significantly different at 5 % level.

*zero time.

Table (4): Effect of postharvest application of ethephon on the fruit quality of Washington Navel orange fruits in 2004 and 2005 seasons.

Concentration (ppm)	Soluble solids content (SSC %)					Titrable acidity (%)					SSC / acid ratio				
	Storage period (days)				Average	Storage period (days)				Average	Storage period (days				Average
	0*	5	10	15	(A)	0*	5	10	15	(A)	0*	5	10	15	(A)
							1^{st} season (2004)								
Control	9.5	10.1	10.8	9.4	9.7 ^{a}	0.85	0.84	0.74	0.64	0.73 ^{bc}	11.5	12.6	16.4	13.8	13.6 ^{abc}
200	9.5	9.4	10.2	9.9	9.6 ^{a}	0.85	0.81	0.65	0.74	0.76 ^{abc}	11.5	11.9	15.3	14.2	13.2 ^{bc}
300	9.5	10.3	10.6	10.5	10.0 ^{a}	0.85	0.69	0.65	0.74	0.73 ^{bc}	11.5	13.9	17.3	14.0	14.2 ^{a}
400	9.5	9.5	10.4	9.9	9.7 ^{a}	0.85	0.78	0.70	0.66	0.74 ^{abc}	11.5	12.2	15.3	14.9	13.5 ^{abc}
500	9.5	9.5	9.9	10.7	9.8 ^{a}	0.85	0.81	0.80	0.67	0.78 ^{a}	11.5	11.6	12.7	15.4	12.8 ^{c}
1000	9.5	9.9	10.4	10.3	9.4 ^{a}	0.85	0.76	0.72	0.68	0.75 ^{ab}	11.5	12.8	15.1	14.5	13.5 ^{abc}
1500	9.5	10.3	10.4	10.2	10.0 ^{a}	0.85	0.78	0.81	0.67	0.73 ^{bc}	11.5	13.4	14.4	14.9	13.6 ^{abc}
2000	9.5	9.6	10.1	10.2	9.8 ^{a}	0.85	0.78	0.75	0.65	0.71 ^{c}	11.5	13.1	15.2	15.6	13.9 ^{ab}
Average (B)	9.5 B	9.5 B	10.3 A	10.1 A		0.85 A	0.77 B	0.67 C	0.68C		11.5 C	12.7 B	15.2 A	14.7 A	
							2^{nd} season (2005)								
Control	9.4	8.9	9.9.	10.6	9.6 ^{c}	0.85	0.90	0.77	0.76	0.82 ^{a}	12.1	9.8	12.8	13.9	12.2 ^{e}
200	9.4	9.6	9.4	10.2	9.6 ^{c}	0.85	0.91	0.63	0.81	0.80 ^{b}	12.1	10.5	14.9	12.5	12.5 ^{de}
300	9.4	9.5	10.1	10.7	9.9 ^{b}	0.85	0.90	0.66	0.76	0.79 ^{bc}	12.1	10.5	15.1	13.9	12.9 ^{cd}
400	9.4	9.4	9.7	10.6	9.7 ^{bc}	0.85	0.82	0.64	0.75	0.77 ^{d}	12.1	11.4	14.9	13.9	13.1 ^{bc}
500	9.4	8.9	9.7	10.4	9.7 ^{c}	0.85	0.79	0.75	0.74	0.78 ^{bc}	12.1	11.2	13.2	14.0	12.6 ^{cde}
1000	9.4	9.3	9.9	10.8	9.8 ^{bc}	0.85	0.78	0.69	0.79	0.78 ^{cd}	12.1	11.8	14.3	13.6	12.5 ^{cd}
1500	9.4	10.4	10.2	10.8	10.2 ^{a}	0.85	0.78	0.69	0.75	0.77 ^{d}	12.1	13.3	14.6	14.2	13.5 ^{b}
2000	9.4	10.7	10.2	10.7	10.2 ^{a}	0.85	0.76	0.64	0.73	0.75 ^{e}	12.1	13.9	15.8	14.5	14.1 ^{a}
Average (B)	9.4 C	9.6 BC	9.9 B	10.6 A		0.85 A	0.83 B	0.76 C	0.68 D		12.1 B	11.5 B	14.5 A	13.8 A	

LSD 5 % A X B 2004 = ns 2005= ns 2004 = ns 2005= ns 2004 = ns 2005 = ns

Values with the same small letter in each column or capital letter in each raw are not significantly different at 5 % level.

* zero time.

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تحسين تلوين ثمار البرتقال بسره بإستخدام الإثيفون

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أجرى هذا البحث بهدف دراسة تأثير الرش بالإثيفون قبل الجمع (صفر، ١٥٠، ٢٠٠ ، ٣٠٠، ٤٠٠، ٥٠٠ جزء فى المليون) و بعد الجمع (صفر ، ٢٠٠ ، ٣٠٠، ٤٠٠، ٥٠٠ ، ١٠٠٠ ، ١٥٠٠ ، ٢٠٠٠ جزء فى المليون) على درجة التلوين والمكونات الكيماوية لثمار البرتقال بسره.

أدى رش الإثيفون بتركيز ٤٠٠ جزء فى المليون مع إضافة خلات الكالسيوم بتركيز ١ % قبل الجمع إلى تبكير جمع المحصول ١٠ أيام ، و انخفاض ملحوظ فى نسبة تساقط الثمار و الأوراق خاصة بعد ٢٠ يوماً من المعاملة.

كما أدت المعاملة بالإثيفون سواء قبل أو بعد الجمع إلى سرعة تلوين الثمار و زيادة محتوى العصير من المواد الصلبة الذائبة و إنخفاض الحموضة به. و لقد أظهر الإثيفون إنخفاضاً فى محتوى القشرة من الكلوروفيل و زيادة الكاروتينويدات و كان ذلك مرتبط بالتغيرات فى لون القشرة و ملازم للزيادة فى تركيز الإثيفون. أدت إطالة فترة تخزين الثمار لمدة ١٥ يوماً إلى زيادة سرعة تلوين الثمار و محتوى العصير من المواد الصلبة الذائبة ، و كذلك محتوى القشرة من الكاروتينويدات ، بينما انخفض الكلوروفيل و كذلك محتوى العصير من الحموضة. و قد لوحظ إنخفاض شديد فى معدل الفقد فى وزن الثمار عند معاملة الثمار بعد الجمع بالإثيفون بتركيز ١٥٠٠ جزء فى المليون و تخزينها لمدة ١٥ يوماً.