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تأثير الرش بالبوتاسيوم قبل الحصاد على صفات الجودة والقدرة التخزينية لثمار البرتقال أبو سرة

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الملخص العربي

أجريت هذه الدراسة على أشجار البرتقال أبو سرة والنامية بمزرعة خاصة، القليوبية – مصر.

رشت أشجار البرتقال أبو سرة بعد العقد، ثم بعد شهر وقبل الحصاد بشهر خلال موسمي ٢٠٠٨/٢٠٠٩ بالبوتاسيوم (بوتاسيوم ٤٠% بو٢أ) بالتركيزات (١.٠، ٢.٠مل/لتر ماء). وعند وصول الثمار إلى مرحلة اكتمال النمو والصلاحية للقطف، قطفت الثمار فى الأسبوع الأول من ديسمبر خلال موسمي الدراسة. نقلت الثمار إلى المعمل حيث تم غسلها وتجفيفها وفرزها وخزنت على درجة حرارة ١٠°م ورطوبة نسبية ٨٥–٩٠ %.

أوضحت نتائج هذه الدراسة أن رش أشجار البرتقال أبو سرة بالبوتاسيوم بتركيزي (١.٠، ٢.٠ مل/لتر ماء) أدى إلى تحسين صفات الجودة عند الحصاد حيث أدى إلى زيادة وزن الثمار وحجم العصير، ووزن وسمك القشرة، المواد الصلبة الذائبة الكلية، فيتامين ج وتحسين لون الثمار ولكنها أدّت إلى ارتفاع نسبة الحموضة.

أدت معاملات ما قبل الحصاد إلى تحسين صفات الجودة والمقدرة التخزينية للثمار أثناء التخزين المبرد على ١٠°م وتقليل الفقد الكلى (الفقد فى الوزن ونسبة التالف) وكانت ذا تأثير معنوي مقارنة بثمار المقارنة (٣٢.١٩، ٣٠.٦٣ %) في كلا الموسمين.

أدت المعاملات المختبرة إلى خفض معدل الفقد فى المواد الصلبة الذائبة الكلية، الحموضة الكلية وفيتامين ج أثناء التخزين مقارنة بثمار المقارنة.

EFFECT OF PRE HARVEST POTASSIUM SPRAYS ON FRUIT QUALITY AND STORABILITY OF WASHINGTON NAVEL ORANGES

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ABSTRACT: *Mature trees of "Washington" Navel orange (Citrus sinensis, L.) growing in a clay soil at Kaloubia Governorate, Egypt, were sprayed after fruit set, a month later and a month pre harvest in 2008 & 2009 seasons, with two levels (1.0 and 2.0 ml L^{-1}) of potassium (40 % K_2O.) Mature fruits were harvested and stored at 10°C for 12 weeks. Results at harvest showed that pre harvest potassium sprays increased fruit weight at (2.0 ml L^{-1}) (260 & 330g) as compared with control (167 & 220 g) in both seasons, respectively. In addition, juice volume, rind weight, rind thickness and total soluble solids. Content of ascorbic acid and total acidity were also increased significantly, as compared with control. As well as peel color improvement as compared with control*

Pre harvest treatments especially, at (2.0 ml L^{-1}) were effective in improving fruit quality and storability of "Washington" Navel orange during storage at 10 °C., as it reduced the total loss (decay % + weight loss %) by (22.57 & 21.63 %) as compared with the control (32.19 & 30.63 %), in both seasons, respectively.

Fruit weight loss was reduced by (13.08 %) as compared with control (18.58 %) in the first season. The same trend was noticed for total losses (decay % and weight loss %) without significant differences between the two levels of potassium. Moreover, it maintained peel colour and reduced total acidity, while the of loss rate TSS and ascorbic acid of K-treated fruit were decreased as compared with control in both seasons during storage.

***Key words**: Washington Navel orange, potassium, foliar spray, cold storage, fruit quality and storability.*

INTRODUCTION

Citrus ranks the first among fruit crops production in Egypt and the second after grapes in the world. Citrus fruits are the most important in the world trade for their fresh fruit consumption and export market. The total area of citrus in Egypt increased from about 214000 feddans (1983) to 462772 feddans (2010). From such area, 163633 feddans are cultivated by Washington Navel orange (the feddan produces, an average, 9.83 ton per year). Navel orange occupies about 35% of the total citrus area. It's an important source of early season income for citrus growers in some commercial citrus areas of the world (Krezdorn, 1969).

Although extraordinary efforts have been executed, in the last few years, to increase the acreage and production of citrus, the exports of fresh citrus to foreign markets is still limited (aprox.10% from total citrus production). Therefore, reducing post-harvest losses is important for extending the season of Egyptian exports of Washington Navel orange.

Potassium is one of the pre-harvest treatments which have been used to control many of physiological and chemical changes affecting fruit quality. Potassium may have an influence on the incidence of physiological disorders; it has an important role in the maintenance of cellular organization by regulating the permeability of cell membranes.

Cold storage at optimum temperature and humidity is the best method to extend storage life and reduce disorders, i.e., rind breakdown, shriveling and other defects of citrus fruits especially, Navel orange.

The present investigation aims to study the effect of pre harvest foliar sprays of potassium at two levels (1.0 and 2.0 ml L^{-1}) on fruit quality at harvest time and storability of "Washington" Navel orange fruits to reduce losses during cold storage at 10°C (as transportation and shipment temperature).

MATERIALS AND METHODS

Pre harvest treatments:-

The present investigation was carried out during two successive seasons of (2008 and 2009) on mature healthy "Washington" Navel orange (*Citrus sinensis,* L.) trees, thirty five years old, grafted on Sour orange (*Citrus aurantium,* L.) rootstock grown in a private orchard at Kaloubia Governorate, Egypt, to study:-

The influence of foliar sprays of potassium at (1.0 and 2.0 ml L^{-1}) after fruit set, a month later and a month pre harvest and the effect of cold storage (10°C and 85-90% R.H.) on fruit quality and storability of "Washington" Navel orange fruits.

The experimented trees grown in a clay soil, nearly uniform in vigor and subjected to the same cultural practices, were selected and divided into three groups, each group (consisted of six trees as three replicates) subjected to one of the following treatments :-

1- Foliar sprays with tap water (control).

2- Foliar sprays with 1.0 ml L^{-1} of potassium.

3- Foliar sprays with 2.0 ml L^{-1} of potassium.

The obtained data were handled as follows:

Fruit quality

At the 1st week of December, of both seasons, mature Orange fruits were harvested at maturity stage according to Abd El-Hafeez (1998) and directly transported to the laboratory of Fruit Handling Research Department. Uniform fruits of each treatment were washed, air dried and packed in carton boxes in one layer and stored at 10°C with 85-90 R.H.

Fruit quality assessment

For physical and chemical determination during cold storage, a sample consists of 3 fruits was taken randomly from each replicate within each treatment at 2 weeks interval for decay %, weight loss %, total loss and three weeks for others.

1-Fruit physical characteristics:

1.1 Average of fruit weight at harvest (g).

Fruit weight (g) was calculated.

1.2. Fruits decay percentage (rind disorders).

Decayed fruits are characterized by rind breakdown, shriveling and other defects; these disorders of fruits were calculated as decay fruit percentage.

1.3 Fruit weight loss (%). Fruit weight loss was recorded and calculated as percentage.

1.4 Total loss percentage **=** Fruit decay percentage (rind disorders) + Fruit weight loss (%).

1.5. Peel color measurements.

Peel color of fruit was measured by taking the average of two measurements on two opposite points of each fruit equator with a Minolta colorimeter (Minolta Co. Ltd., Osaka, Japan) on the basis of the CIELAB color system. In this system values of (a & b) specify the green-red and blue-yellow axis, while Hue (h◦) determines the position of such vector. (h◦) values are calculated based on a and b values according to the following equation: - $h^{\circ} = 180 \pm \tan^{-1}(b/a)$.

Values were determined and calculated according to (McGuire, 1992).

1.6 Juice volume (ml): It was determined to the nearest ml and recorded.

1.7 Rind weight (g): was recorded and calculated

1.8 Rind thickness (mm): It was measured by digital caliper; the average peel thickness was calculated and recorded for each sample.

2. Fruit chemical characteristics

2.1. Total soluble solids (T.S.S) percentage:

T.S.S was determined by using Carl

Zeiss hand refractometer.

2.2. Total acidity percentage: was determined in fruit juice as citric acid according to A.O.A.C, (1985).

2.3. Ascorbic acid (Vitamin C) content: was calculated as mg/100 ml juice according to A.O.A.C, (1985).

3- Statistical analysis

All obtained data in both seasons were subjected to analysis of variance according to Snedecor and Cochran (1989). Differences among means for the specific effect of storage period and the tested pre harvest treatments were compared using Duncan's Multiple Range test (Duncan, 1955) at $p \leq 0.5$.The interaction effect between treatments and storage periods were differentiated using L. S. D. at $p \leq 0$.

RESULTS AND DISCUSSION

1. Fruit quality at harvest:

1.1. Fruit weight.

Data presented in Table (1) show that average fruit weight was increased as affected by potassium sprays, especially K at 2.0 ml L^{-1} (260 & 330 g) as compared with the control (167 & 220 g) in both seasons without significance between the two levels of potassium. These results go in line with those obtained by Chu (1963) on mandarin trees found that the fruit weight and TSS was increased with K application at 0, 200 or 300 g/tree/year. Abaev (1973) noted that raising the K level from 30 kg K_2O/ha to 60 kg K_2O/ha, resulted in the largest fruit size of lemon as well as El-Shobaky and Mohamed (2000) on Washington Navel orange.

1.2. Juice volume, rind weight and thickness.

Data in Table (2) show that juice volume, rind weight and thickness of K-treated fruits were significantly increased as compared with the control in both seasons. These results go in line with those obtained by Embleton *et al*., (1967) who found that an increase of the K level in the range of 0.3 to 1.7 % resulted in thicker and coarser textured rind that has subjected to delayed colour break and to more greening also (El-Shobaky and Mohamed, 2000) on Washington Navel orange.

1.3. Total soluble solids, total acidity percentage and ascorbic acid content.

Table (3) shows that changes in total soluble solids were significantly slightly increased as affected by pre harvest sprays of K at (1.0 & 2.0 ml L^{-1}), these values were (11.8 & 12.3 %) and (11.9 & 12.4 %) in both seasons as compared with control (11.3 & 11.4 %) respectively, without significance among treatments. Table (3) shows that total acidity was significantly decreased as affected by pre harvest sprays of K at (1.0 & 2.0 ml L^{-1}) in both seasons as compared with control (El-Shobaky and Mohamed, 2000) on Washington Navel orange.

Data in Table (3) shows that ascorbic acid content was significantly increased as affected by pre harvest sprays of K at (1.0 & 2.0 ml L^{-1}) in both seasons as compared with control. These results go in line with those obtained by (El-Hilali *et al*., 2002) which indicate that preharvest foliar spray with calcium and potassium increase juice acid content in treated "Fortune" mandarin fruits over the control.

2. Fruit quality during storage:

2.1. Decayed fruits percentage.

Data presented in Table (1) show that fruit decay % had significantly increased long as the storage period advances under cold storage (10°C.) Foliar sprays of potassium at (1.0 and 2.0 ml L^{-1}) cleared much lower values of decayed fruits percentage, especially K at 2.0 ml L^{-1} 9.52 % (first season) and (potassium at 1.0 ml L^{-1}) 9.98 % (second season) as compared with the control (13.63 and 13.25 %), respectively. The interaction effect of storage period and pre harvest treatments showed high significant effect on fruit decay % in both seasons. These observations go in line with those obtained by (Kassem and El-Sabrout, 2002) showed that increasing K fertilization rates decreased fruit decay.

Table 1

Table 2

Table 3

2.2. Weight loss percentage.

It is obvious from Table (1) that weight loss % had significantly increased by prolonging the storage periods. The tested pre harvest treatments revealed high reduction effect in fruit weight loss as compared with the control, especially, K at (2.0 ml L^{-1}) 13.08 % (first season) and K at (1.0 ml L^{-1}) 11.7% (second season) than control (18.58 & 17.42 %) in both seasons, respectively. These observations go in line with those obtained by El-Zawily (2004) when N and K fertilizers were used.

2.3. Total loss percentage (Fruits decay % + Fruit weight loss %).

Data in Table (1) showed that total loss % of fruits were significantly affected by potassium sprays in both seasons. Potassium sprays (2.0 %) induced the lowest values (22.57 & 21.63 %) than control (32.19 & 30.63 %) in both seasons. The obtained results were in harmony with those found by Kassem and El-Sabrout (2002) and El-Zawily (2004).

2.4. Juice volume, rind weight and thickness.

Data in Table (2) show that Juice volume, rind weight and thickness of K-treated fruits were significantly decreased by prolonging the storage periods as compared with the control in both seasons. These results go in line with those obtained by Abd-Alla (2006), Abd El-Migeed *et al.* (2000) and Saleh *et al.* (2001) 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.

2.5. Peel colour.

Fig (1) illustrated that potassium sprays maintained peel color as compared with control at harvest and during cold storage.

The obtained data are in harmony with the results of Embleton *et al*., (1967) who found that an increase of the K level in the range of 0.3 to 1.7 % resulted in thicker and coarser textured rind that has been subjected to delayed colour break and to more greening also.

2.6. Total soluble solids, total acidity percentage and ascorbic acid content.

It is obvious from Table (3) that changes in total soluble solids were significantly slightly increased by extending the storage periods and slightly increased as affected pre harvest sprays of K at (1.0 & 2.0 ml L^{-1}) (13.22 & 13.32 %), (13.44 & 13.40 %) without significant differences in both seasons as compared with control (12.30 & 12.38 %) respectively.

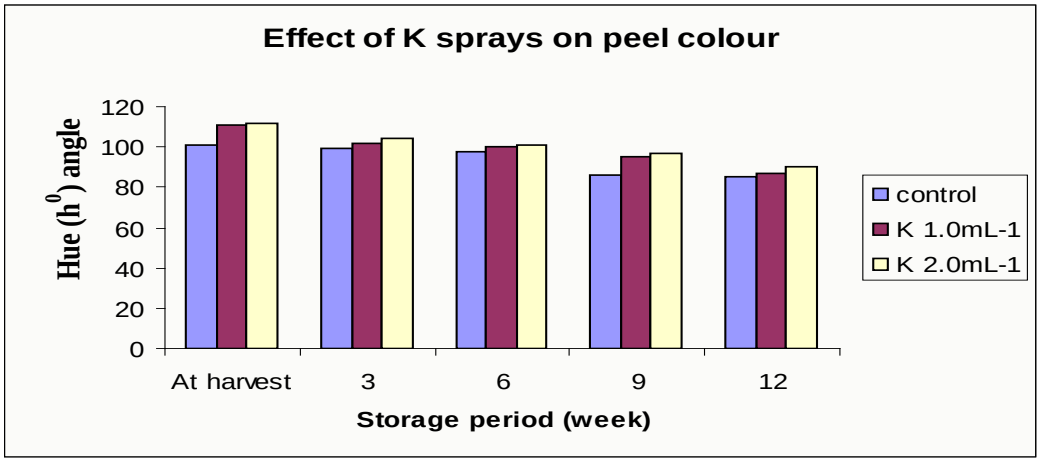

Fig. (1): Effect of potassium sprays on peel colour of Washington Navel orange fruits at harvest and during cold storage (average of two seasons).

Table (3) illustrate that total acidity that was significantly decreased as affected by pre harvest sprays of K at (1.0 & 2.0 ml L^{-1}) in both seasons as compared with control.

Data in Table (3) showed that ascorbic acid content was significantly increased as affected by pre harvest sprays of K at (1.0 & 2.0 ml L^{-1}) in both seasons as compared with control. These results go in line with those obtained by Helal (1999), El-Shobaky and Mohamed (2000), Srivastava *et al*. (2001), Kassem and El-Sabrout (2002), El-Zawily (2004) and Zaghloul *et al*. (2011) on Washington" Navel orange fruits.

CONCLUSION

It is preferable to spray Washington" Navel orange fruits with potassium at (1.0 and 2.0 ml L^{-1}) after fruit set, a month later and a month pre harvest and store the fruits at (10°C and 85-90 % R.H.), to enhance fruit quality at harvest and during storage period up to 12 weeks.

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Table (1): Effect of pre harvest potassium sprays on fruit weight at harvest decay %, weight loss % and total losses % and during storage at (10 ^{o}C) of Washington Navel orange fruits in 2008 & 2009 seasons.

Season / Characters. / S.P. / Treat.	Fruit weight	Decay %							Weight loss %							Total loss						
		2	4	6	8	10	12	Mean	2	4	6	8	10	12	Mean	2	4	6	8	10	12	Mean
First season (2008)																						
Control	167B	0.00	6.40	11.20	17.80	20.20	26.10	13.63A	4.40	8.90	15.20	22.60	26.20	34.20	18.58A	4.40	15.30	26.40	40.40	46.40	60.27	32.19A
T1 (1.0 ml L-1 of potassium)	253.3A	0.00	4.10	6.90	11.60	13.10	17.10	8.80C	3.60	7.70	11.40	17.50	18.50	25.00	13.95B	3.60	11.80	18.30	29.33	31.60	42.00	22.78B
T2 (2.0 ml L-1 of potassium)	260.0A	0.00	4.40	7.40	12.50	14.30	18.50	9.52B	3.20	6.60	10.90	16.10	18.00	23.70	13.08C	3.20	11.00	18.30	28.40	32.30	42.20	22.57B
Mean		0.00F	4.97E	8.50D	13.97C	15.89B	20.57A		3.73F	7.73E	12.50D	18.73C	20.90B	27.63A		3.73F	12.70E	21.00D	32.72C	36.77B	48.16A	
L.S.D. at ≤ 0.05	13.56	T = 0.091		P = 0.129		T x P = 0.223			T = 0.299		P = 0.423		T x P = 0.733			T = 0.245		P = 0.347		T x P = 0.601		
Second season (2009)																						
Control	220B	0.00	5.50	10.80	17.60	20.10	25.50	13.25A	3.90	8.00	14.60	22.00	24.00	32.00	17.42A	3.90	13.30	25.40	39.60	44.10	57.50	30.63A
T1 (1.0 ml L-1 of potassium)	325A	0.00	1.80	3.60	12.50	19.30	20.40	9.98B	3.00	6.50	11.00	11.00	18.20	20.50	11.70C	3.00	8.80	15.90	25.30	35.70	41.40	21.68B
T2 (2.0 ml L-1 of potassium)	330A	0.00	2.30	4.90	14.30	17.50	20.90	9.55C	2.90	5.90	10.70	15.70	17.50	19.87	12.09B	2.90	7.70	14.30	28.20	36.50	40.20	21.63B
Mean		0.00F	3.20E	6.43D	14.80C	18.87B	22.27A		3.30F	6.80E	12.10D	16.20C	19.90B	24.12A		3.27F	9.93E	18.53D	31.03C	38.77B	46.37A	
L.S.D. at $p \leq 0.05$	14.92	T = 0.109		P = 0.155		T x P = 0.268			T = 0.253		P = 0.357		T x P = 0.619			T = 0.244		P = 0.346		T x P = 0.60		

Table (2): Effect of pre harvest potassium sprays on some physical properties of Washington Navel orange fruits at harvest and during storage at (10 °C) in 2008 & 2009 seasons.

Season	First season (2008)																	
Characters.	Juice volume						Rind weight						Rind thickness					
S.P. / Treat.	0	3	6	9	12	Mean	0	3	6	9	12	Mean	0	3	6	9	12	Mean
Control	60.00	57.80	55.00	51.00	48.00	54.36B	34.00	30.10	27.00	23.50	19.50	26.82C	0.53	0.47	0.41	0.36	0.31	0.42C
T1 (1.0 ml L-1 of potassium)	88.50	85.00	82.00	78.00	72.00	81.10A	58.00	51.00	47.00	42.00	36.00	46.80B	0.59	0.52	0.46	0.42	0.36	0.47B
T2 (2.0 ml L-1 of potassium)	92.00	89.00	85.00	82.00	76.00	80.20A	60.00	54.00	49.00	45.00	38.00	49.20A	0.60	0.58	0.52	0.46	0.40	0.51A
Mean	80.17A	77.27A	74.00B	70.33C	57.67D		50.67A	45.03B	41.00C	36.83D	31.17A		0.57A	0.52B	0.46C	0.41D	0.36E	
L.S.D. at ≤ 0.05	T = 2.37		P = 3.06		T x P = 5.31		T = 0.94		P = 1.21		T x P = 2.10		T = 0.024		P = 0.031		T x P = 0.053	
Second season (2009)																		
Control	78.50	76.00	73.40	70.00	67.50	73.10C	40.60	35.80	32.00	27.00	22.50	31.58C	0.45	0.42	0.38	0.35	0.32	0.38B
T1 (1.0 ml L-1 of potassium)	110.00	106.00	102.00	96.00	88.00	100.40B	70.00	64.00	58.00	49.00	40.00	56.20A	0.48	0.46	0.42	0.39	0.36	0.42A
T2 (2.0 ml L-1 of potassium)	115.00	112.00	108.00	102.00	98.00	107.0A	68.00	63.00	55.00	46.00	40.00	54.40B	0.50	0.48	0.44	0.41	0.38	0.44A
Mean	101.20A	98.00B	94.47C	89.33D	84.50E		59.53A	54.27B	48.33C	40.67D	34.17E		0.48A	0.45A	0.41B	0.38BC	0.35C	
L.S.D. at $p \leq 0.05$	T = 1.84		P = 2.37		T x P = 4.11		T = 1.29		P = 1.66		T x P = 2.88		T = 0.025		P = 0.032		T x P = 0.055	

Table (3): Effect of pre harvest potassium sprays on some chemical characteristics of Washington Navel orange fruits at harvest and during storage at (10 °C) in 2008 & 2009 seasons.

Season	First season (2008)																	
Characters.	T.S.S.						Total acidity						Vitmain C					
S.P. / Treat.	0	3	6	9	12	Mean	0	3	6	9	12	Mean	0	3	6	9	12	Mean
Control	11.30	12.00	12.30	12.70	13.20	12.30B	0.97	0.94	0.91	0.87	0.84	0.91C	38.00	35.20	32.50	30.20	28.50	32.88C
T1 (1.0 ml L-1 of potassium)	11.80	12.80	13.30	13.80	14.40	13.22A	0.98	0.97	0.95	0.90	0.86	0.93B	43.00	38.70	37.10	35.30	35.00	41.50A
T2 (2.0 ml L-1 of potassium)	11.90	13.10	13.40	14.30	14.50	13.44A	0.99	0.98	0.95	0.91	0.87	0.94A	45.10	41.90	40.90	40.60	39.00	37.82B
Mean	11.67C	12.63B	13.00B	13.60A	14.03A		0.98A	0.96B	0.94C	0.89D	0.86E		42.03A	38.60B	36.83C	35.37D	34.17E	
L.S.D. at ≤ 0.05	T = 0.459		P = 0.593		T x P = 1.03		T = 0.0075		P = 0.0097		T x P = 0.0167		T = 0.579		P = 0.747		T x P = 1.294	
Second season (2009)																		
Control	11.40	12.00	12.40	12.80	13.30	12.38B	0.96	0.93	0.89	0.86	0.82	0.893C	40.00	38.20	36.30	34.60	32.00	36.22C
T1 (1.0 ml L-1 of potassium)	12.30	12.80	13.10	13.80	14.60	13.32A	0.98	0.96	0.92	0.89	0.87	0.924A	42.00	41.50	41.20	41.00	40.30	41.20B
T2 (2.0 ml L-1 of potassium)	12.40	12.70	13.20	13.90	14.80	13.40A	0.97	0.95	0.94	0.88	0.84	0.916B	44.00	42.50	42.00	41.50	41.00	42.20A
Mean	12.03D	12.50CD	12.90C	13.50B	14.23A		0.97A	0.95B	0.91C	0.88D	0.84E		42.00A	40.73B	39.83BC	39.03C	37.77D	
L.S.D. at $p \leq 0.05$	T = 0.457		P = 0.590		T x P = 1.02		T = 0.0078		P = 0.010		T x P = 0.0175		T = 0.756		P = 0.976		T x P = 1.691	