International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume:03, Issue:01

MAXIMIZING THE PROFITABILITY OF THE FARMERS BY ON TREE STORAGE OF BALADY MANDARIN

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ABSTRACT

To get a high economic return of mandarin productivity, some growers tend to expand harvest period by keeping fruits for longer time on the trees in order to extend marketing season. Hence this study was carried out during the two seasons (2016 and 2017) to evaluate foliar applications of some chemicals on-tree storage intervals (fourth harvest periods) of Balady mandarin. Forty years old of Balady mandarin (Citrus reticulate Blanco) trees budded on sour orange rootstock (Citrus aurantium, L.Osbeck) planted at 5x5m apart and growing in loam clay soil in a private orchard located at El Menofia Governorate. The experiment involved eight treatments and its concentrations carried out at fruit color break as follows 10,20 ppm gibberellic acid; 10,15ppm 2,4- D (2,4-Dichlorophenoxyacetic acid); 2% Calcium nitrate + 0.1% Boric acid ;10 ,20ppm Cobalt sulfate and control treatment(untreated trees). The obtained results indicated that, all treatments gave the best results; especially the application of 2, 4-D at 15ppm was the best treatment for reducing average fruit drop rate (%) and for achieving the highest fruit weight, and fruit juice weight percentage, TSS / Acid ratio and have thicker fruits peel. Also, GA3 at 20ppm had superior impact by delaying the over ripe rind color development, increased peel firmness (peel puncture resistance) and fruit vitamin C content. On the other hand, storage fruits on the tree till the beginning of March (3rd harvest) was the best period for keeping the fruit quality. Anatomy study revealed that, cells in the abscission zones were very compact with no extracellular spaces which are smaller than the neighboring cells. It could be recommended the possibility of prolonging the storage of Balady mandarins on the tree with maintained fruit quality until early March, by spraying the trees with 2, 4-D at 15ppm to maximize the profitability of the grower. Prolonging storage of fruits on trees after this time lead to a decrease in internal fruit quality under the experiment conditions.

Keywords: Balady mandarin, on tree storage, 2, 4-D, GA3, fruit quality and anatomy study.

INTRODUCTION

Mandarin (Citrus reticulate Blanco) is a promising citrus export for Egypt. Harvesting time may change from year to year. It generally starts at the beginning of February, and the rest of the fruit ages on tree. During years of heavy production, growers are obliged to store fruits on the tree or in cold rooms when the market is saturated (El-Otmani, et al., 1990). Packing house operations of mandarins begin at the regions where the fruits ripen earlier with the expected quality to be harvested. It is followed by other regions. Because of limited capacity of packing houses, insufficient number of workers and unsuitable climatic factors for harvest, the harvesting period may last up to two months. Thus, some growers tend to expand harvest period by keeping the fruits for longer time on the trees in order to extend marketing season, for a high economic return (Marzouk and Kassem, 2010). As on-tree storage time is extended, quality losses related to fruit peel aging, puffing and fruit dropping tend to rise and the fruits will become more susceptible to many types of disorders and diseases. Increased incidence of fruit drop would depend on many factors including on-tree storage time, climatic conditions and pests and diseases, and the drop rates may go up to as high as 20% in the case of 1 month delayed harvest (Şen, et al., 2009).

Growth regulators application is one of several tools when properly used enables citrus growers to extend marketing period with no loss of fruit quality (Ismail, 1997). Pre-harvest application of GA3 has been reported to delay peel aging, decay, deterioration and coloring and reduces disease loss on many citrus species (Garcia-Luis et al., 1992). As a consequence, on-tree storage would be possible to extend the harvest period. Thus, GA3 application is suggested especially for late harvested lemon (El-Zeftawi, 1980a), grapefruit (El-Zeftawi, 1980b), and mandarin cultivars (Şen, et al., 2009). Preharvest GA3 applications were found to be ineffective or less effective on internal quality of many citrus fruits (Pozo, et al., 2000). Also, coloration is delayed by pre-harvest GA3 application at 5 and 10 ppm concentrations. However the effect was significantly decreased by late applications and especially with applications after the start of coloration (Ben-İsmail, et al., 1995). In addition, pre-harvest sprays of 2, 4-D alone or with GA3 proved to be effective in better peel quality of on tree stored fruit, and reducing late season fruit drop therefore, extending the harvest season, as well as retarding rind senescence and lowering fruit decay (Golddchmidt and Eilati 1970, Ismail,1997). Information on the absorption and excretion of 2, 4-D in several species indicates that the compound is rapidly excreted unchanged, and that it is not stored in the tissues in mammals. According to FAO/WHO (1972), the acceptable daily intake 2, 4-D for man allocated as 0 to 0.3mg kg-1 body weight. Washington Navel oranges were sprayed with 20mg kg-1 2, 4-D as practiced for growth regulation and pre-harvest fruit drop. Orange samples were taken before, 1 day after and 7 days after spraying. Residues of 2, 4-D averaged < 0.1mg kg-1 before, 0.1mg kg-1 1 day after, and < 0.1mg kg-1 7 days after treatment (Erickson and Hield, 1962). Moreover, fruit maturity can be delayed and storage ability would be

ISSN: 2455-6939

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improved with pre-harvest Calcium (Ca) applications (Gerasopoulus, et al., 1996). Postharvest losses can be minimized by using appropriate pre-harvest growth regulators and Ca applications that delayed ripening, increase peel strength and resistance. With the Ca application the solidity of the peel texture was enhanced and the fruit become more resistant to pathogenic attacks (Davis, 1986; Conway, et al., 1994).These positive effects of Ca could also be useful on on-tree storage. Also, cobalt (Co) is beneficial for some plants and it is essential for plant growth and component of several enzymes and co-enzymes (Palit, et al., 1994). Its beneficial effects include retardation of leaf senescence, inhibition of ethylene biosynthesis, and stimulation of alkaloid biosynthesis (Palit, et al., 1994). In this respect, Naqvi, et al., (1990) have demonstrated besides the growth regulator NAA, aqueous spray applications of Co and Ag also effectively enhanced fruit yield in Elite mango cultivars. They also found that the applications of 100 mg/l Co (NO3)2, 100 mg/l Ag NO3, 20 mg/l NAA and 50 mg/lGA3 enhanced mango fruit retention by 131, 127, 100 and 50%, respectively compared to control (Naqvi, et al., 1992). Foliar application of cobalt sulphate have been resulted in increasing fruit set and retention, fruit yield, weight, size and TSS: acid ratio and total sugars in many mango cultivars (Singh and Agrez, 2002).

The aim of this study was to get a high economic return for mandarin growers by keeping the fruit for longer time on the trees to extend marketing season, and thus by studying the effect of foliar application of some chemicals on Balady mandarin fruits and its effect on fruit physical and chemical changes during on-tree storage.

MATERIAL AND METHODS

Forty years old of Balady mandarin (Citrus reticulate Blanco) trees budded on sour orange rootstock (Citrus aurantium, L. Osbeck) planted at 5x5m apart and growing in loam soil in a private orchard, belong to Mr. Yehia El-Hoseiny located at El Menofia Governorate. , Egypt were selected for two seasons (2016 and 2017). The experiment area was irrigated by flood irrigation system. Twenty four of Balady mandarin trees were used according to growth and vigor during the fruiting for data collection.

A complete randomized block design with three replicates for each treatment was done. The experiment involved eight treatments and its concentrations as follow:

1- Control (untreated)

2- 10ppm gibberellic acid (GA3).

3- 20ppm gibberellic acid (GA3).

4- 10ppm 2, 4-D.

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5- 15ppm 2, 4-D.

6- 2% Calcium nitrate + 0.1% Boric acid.

7- 10 ppm Cobalt sulphate.

8- 20 ppm Cobalt sulphate.

All treatments were added to whole trees at fruit color break. A non- ionic wetting agent (Triton AG-98) was used at a rate of 12 ml per 100 L of solution. Treatments were applied to the point of run- off by spraying (~8 L) the foliage all over the tree with a pneumatic back sprayer. Nitric acid was added to decrease water pH values to 6-7.

PARAMETERS

Fruit drop percentage: Four harvesting intervals were conducted; at the beginning of February, mid February, the beginning of March and in mid March during the two seasons. For each harvest period fruit drop was determined by removing and counting all fruit under the tree canopy, number of dropped fruit was proportioned to the total fruit number per tree and dropped fruit ratio (%) was determined.

Fruit quality: For each harvest period, ten fruits were randomly taken from each replicate and the following determinations were carried out:

Fruit weight (gm): was determined; Juice weight percentage and peel thickness (mm) in each individual fruit were measured by using a digital vernier caliper. Rind firmness (fruit rind puncture resistance force) was measured according to Coggins and Lewis, (1965). Total soluble solids/acid ratio was calculated according to (A.O.A.C, 1995). Ascorbic acid (Vitamin C) was calculated as mg/100 ml juice according to Horwitz, (1972).

Rind color (Hue angle): Rind color measurement (Hue angle) was determined by using a Hunter colorimeter type (DP-9000) for the estimation of a, b and hue angle (h°). In this system of color representation the values a*, and b* describe a uniform two-dimensional color space, where a* is negative for green, and positive for red, and b* is negative for blue and positive for yellow. From a & b values, a/b were calculated Hue angle (hº= arc tan b*/a*) determines the red, yellow, green, blue, purple, or intermediate colors between adjacent pairs of these basic colors Hue angle (0°= red-purple, 90° = yellow, 180°=bluish-green, 270°= blue), as described by (McGuire,1992).

Anatomy study: Mandarin abscission zone was removed from the peel of fruits Fig. (1), and washed with 10% chlorox solution and rewashed with distilled water three times. Specimens

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were killed and fixed for at least 48 hrs. in F.A.A. (10 ml formalin, 5 ml glacial acetic acid and 85 ml ethyl alcohol 70%). The selected materials were washed in 50% ethyl alcohol, dehydrated in a normal butyl alcohol series, embedded in paraffin wax of melting point 56oC, sectioned to a thickness of 20 micron, double stained with crystal violet-erythrosin, cleared in xylene and mounted in Canada balsam (Nassar and El-Sahhar,1998). Slides were analyzed microscopically and photomicrograph.

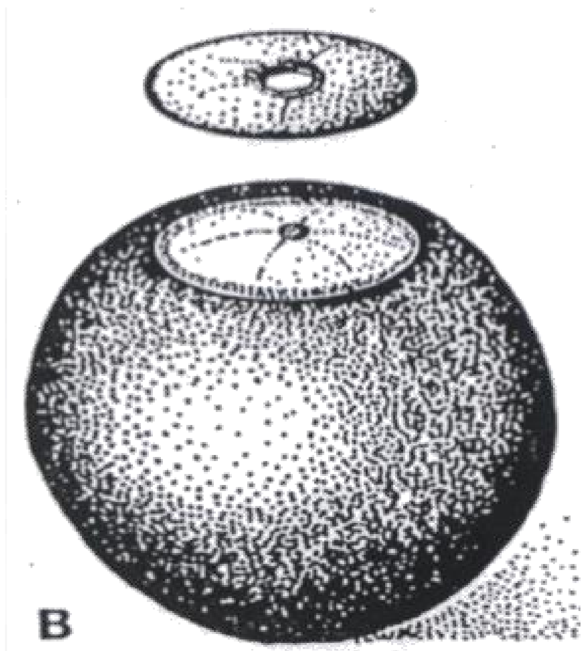

Fig. 1: Schematic representation of technique for the removal of the abscission zone plug.

Statistically analysis. The experiment was designed in a completely randomized block design with three replicates and each replicate was represented by one tree .The obtained data of both seasons were subjected to analysis of variance according to Clarke and Kempson,(1997) and the means were differentiated using Duncan multiple range test at 5% level (Duncan,1955).

RESULT AND DISCUSION

Fruit drop rate (%).The positive influence on decreasing fruit drop by the sprayed substances in our study is obviously shown in (Fig. 2). It is noticed that average fruit drop rate (%) was gradually increased with increasing the period of harvest time, so the maximum fruit drop rate was in the 4th harvest (mid march) while the minimum fruit drop was in the 1st harvest period (beginning of February). On the other hand, fruit drop rate was decreased by all treatments as compared with control in different harvest periods of two seasons (2016 and 2017) whereas, 2, 4-D application at 15 ppm was the best treatment for reducing fruit drop (9.5%) as compared with

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control treatment (27%) in the 4th harvest period whereas the other treatments scored the intermediate values in this regard. It is well established that plant growth regulators are involved in control of abscission (Sexton and Robersts, 1982) this might explain its effect on decreasing fruit drop. In addition, 2, 4-D is widely used in citrus in order to reduce the incidence of mature fruit drop and its primary action is to delay the development of the abscission layer (Coggins, 1973). Also, according to El-Otmani (1992), the combined application of GA3 and 2, 4-D reduces the precocious drop of fruit through the action of auxin and retards the softening and senescence of the peel, by the longer harvest time, and more economical storing in areas where stocking capacity is limited and cost is high. In addition, Almeida, et al ., (2004) mentioned that, spraying with 2,4-D at 10, 20, and 40ppm reduced the rate of fruit drop, compared to control and the rates of drop increase with time, for all the treatments. In this concern, Stewart and Hield (1950) reported that the fall of mature fruit was characterized mainly by alterations in the cellular walls in the zone abscission, localized at the peduncle, and that the main action of plant growth regulators in the fall of ripe fruit was that of reducing the weakening of the cellular wall material in this region, reducing the fall of fruit. This dependence of abscission relative to the endogenous content of auxins has been proven by exogenous applications of 2, 4-D or NAA, as the transportation of auxins by the plant lasts for a long time without ethylene appearing to affect it (Agustí and Almela, 1991). Also, GA3 and Ca sprays influence might be due to the increase in the thickness of both juncture zone and the pedical as well as increasing the connections of vascular system and cell adhesion in union zone as reported for grapefruit by Sayed et al. (2004).

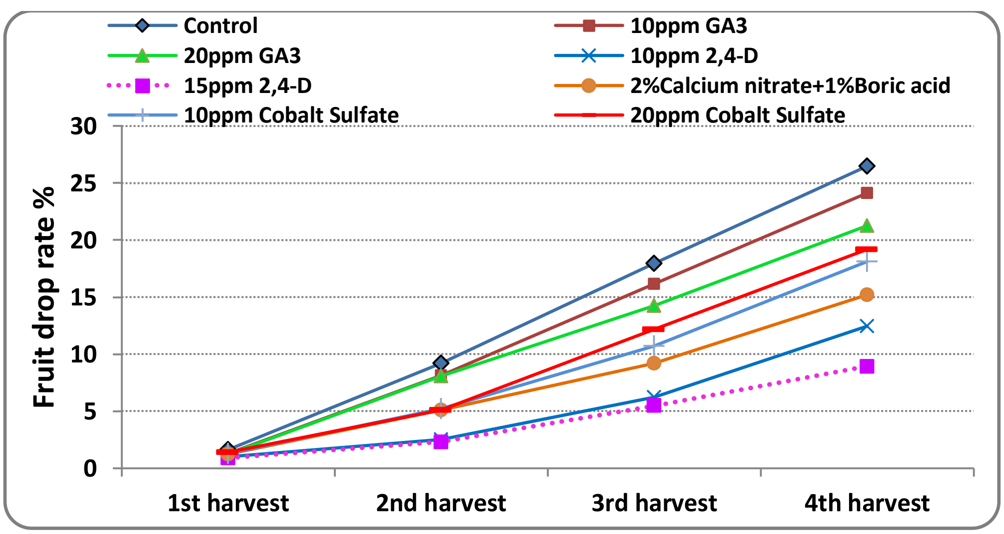

Fig. 2: Average fruit drop rate (%) during different harvest periods of two seasons 2016 and 2017.

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Rind color: Rind color is the considered as the most important and reliable index of citrus fruit. (Fig. 3) showed averages of fruit peel color during different harvest periods of two seasons (2016 and 2017. All treatments delay over ripe rind color development as compared with control treatment. GA3 treated fruits was superior in delaying the over ripe rind color development especially GA3 at 20ppm. In the beginning of February it was greener fruits with GA3 treatments. Likewise at the end of the study (mid March), the color of GA3 treated fruits was yellow-orange color as against of orange with over ripe fruits in control. These findings are in accordance with the findings of the Ladaniya, (1997) in mandarin who stated that GA3 treatments significantly delayed the rind color development in Nagpur mandarin. Kaur, et al., (2008) also observed that color development of the fruits was delayed by gibberellin treatments in plum. Gibberellin has been reported to delay chlorophyll degradation and the senescence in the fruits (EI-Otmani and Coggins, 1991).Color development is associated with a loss of texture, increasing sugar content and decreasing acidity (Rana, 2006). Generally, the effect of GA3 application on delaying green color loss disappeared by time, and at the last harvests its effectiveness was found to be similar with other treatments. Peel coloration is an important sign of physiological development of peel was not directly related with fruit ripening. The effect of GA3 treatments to delay coloration of fruit peel during on-tree storage was previously shown on mandarins (Garcia-Luis, et al., 1992; Şen, et al., 2009), oranges (Ismail and Wilhite, 1992). Also, cobalt (Co) is beneficial for some plants and it is essential for plant growth and component of several enzymes and co-enzymes. Its beneficial effects include retardation of leaf senescence, inhibition of ethylene biosynthesis, and stimulation of alkaloid biosynthesis (Palit, et al., 1994).

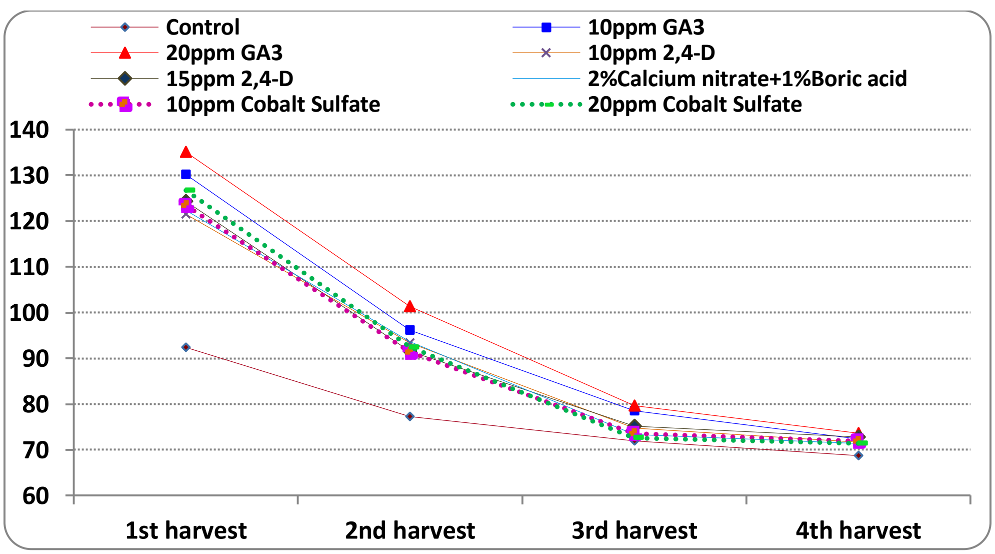

Fig. 3: Averages of fruit rind color during different harvest periods of two Seasons, (2016 and 2017).

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Where: If hue angle measurement is from 140 to 120 the rind color will be **very deep yellow green**, from 120 to 90 the rind color will be **very deep yellow**, from 90 to 60 the rind color will be **very deep orange yellow**, from 60 to 30 the rind color will be very **deep reddish orange.**

Fruit weight (gm): The data presented in (Table 1) indicated that fruit weight varied significantly with the foliar application of different chemicals at different intervals of harvesting period. Fruit weight increased significantly in all the treatments over control and maximum mean fruit weight (135, 139.4gm) was observed in the fruits harvested from trees treated with 2,4-D at 15ppm as compared with control(130.7, 133.7gm) in the first and second seasons, respectively, followed by GA3 treatments whereas, the differences between other treatments were low to be significant. Also, it is noticed that fruit weight increased gradually by increasing harvest period up to 3rd harvest (the beginning of March) then it significantly started to decrease in the 4th harvest (mid March) during the two seasons as compared to the first harvest (in the beginning of February). These finding were in agreement with the findings of Rodrigues, et al., (1963) in Coorg mandarin. However, increase in juice content and fruit weight in Kinnow mandarin (Sandhu, 1992) and Nagpur mandarin (Ladaniya, 1997) was observed with gibberellic acid. Kaur, et al., (2008) has also reported that GA3 at 25 and 50 ppm increased the fruit weight in plum and inconsonance with the observation of (Bose, et al., 1988) who recorded three times increment on fruit weight in mandarin. The increment in fruit weight might be due to hormone directed to transportation and accumulation of phytosynthates which resulted in better fruit development and also acceleration of cell division, elongation, and enlargement. Similar observation was recorded by Daulta and Beniwal (1983) in sweet orange who claimed maximum weight with GA3 sprayed tree fruits. According to Kaur, et al., (2000) fruit weight increased with increase in amount of 2, 4-D in trees of Kinnow mandarin.

Juice weight (%) Juice weight (%) content (Table 1) increased significantly in all the treatments over control .Fruit juice weight percentage was higher (40, 42.9%) in fruits treated by 2, 4 – D (15 ppm) followed by GA3 at 20ppm (39, 42.3%) as compared to control treatment (33.1, 33.6%) during 2016 and 2017 respectively, while calcium nitrate and cobalt sulfate treatments gave the intermediate values in this concern. Also, results indicated that, fruit juice weight (%) increased by increasing harvest period on tree up to first March (3rd harvest) and then it was sharply decreased in mid March (4th harvest), so, the maximum juice weight (41.1, 43.3%) was in the 3rd harvest, while, the minimum juice weight (26, 28.9%) was in the 4th harvest in the first and second seasons respectively. These finding were in agreement with the findings of Rodrigues, et al., (1963) in Coorg mandarin. However, increase in juice content and fruit weight in Kinnow mandarin (Sandhu, 1992) and Nagpur mandarin (Ladaniya, 1997) was observed with gibberellic acid because GA3 treated fruits remained firm and non-treated fruits were over ripe in their condition. Similar observations were recorded by Hari Babu, et al., (1982) in kagzi lime,

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and Daulta and Beniwal (1983) in sweet orange who have reported that GA3 treatments increased the percentage of juice. Increased in juice percentage may also be explained by the fact that hormones play a regulating role in the mobilization of metabolites within a plant and it is well established fact that developing fruits are extremely active metabolic “sinks” which mobilize metabolites and direct their flow from vegetative structure. Also, juice weight % was significantly increased by increasing cobalt sulfate up to 20 ppm on Navel orange trees. In addition, In 'Navel' oranges 20 ppm 2, 4-D application was found to be effective in improving fruit quality (Kassem, et al., 2011).

Peel thickness (mm): Data tabulated in (Table 2) showed the effect of foliar application of some chemicals and prolongation of storage on tree of Balady mandarin on fruit peel thickness. The data of both seasons indicated that all treatments increased fruit peel thickness as compared with control treatment, especially trees treated by 2%Calcium nitrate+ 1%Boric acid and 15ppm 2, 4-D which have thicker fruits while the thinner fruits were obtained by control treatment. On the other hand, concerning the harvest periods, data indicated that fruit peel thickness decreased with increasing the harvest period whereas, the lowest fruit peel thickness was in the late harvest (4th harvest).These results are in the same line with (Marzouk and Kassem, 2010) who mentioned that, spraying calcium increased peel thickness in comparison with the control in Navel orange trees. Also, Dinar, et al., (1977) observed that both GA3 and 2, 4- D increased peel thickness in Marsh grapefruit. On the other hand, peel thickness was significantly increased by increasing cobalt sulfate up to 20 ppm on Navel orange trees (Mansour and Mubarak, 2014).

Peel firmness: Peel firmness or peel puncture resistance is one of the determinants of fruit quality. Results presented in (Table 2) revealed that, all treatments increased peel puncture resistance and GA3 at 20 ppm was superior for resulting in the highest peel firmness (4.98, 5.12mm) followed by calcium treatment (4.67, 4.87mm) while the lowest peel firmness (4.24, 4.16mm) was obtained by control treatment during the two seasons respectively, while 2, 4-D and cobalt treatments recorded intermediate values in this regard. On the other side, it could be noticed that peel puncture resistance decreased with increasing the harvest period. The role of GA3 is not limited only to the regulation of rind color, but also in delaying the more general process of peel ageing (Baez-Sanudo, et al., 1992).

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Table 1: Fruit weight (gm) and Juice weight (%) as affected by some treatments on tree storage of Balady mandarin.

Treatments	Season, 2016									
	Fruit weight (gm)					Juice weight (%)				
	1st harvest	2nd harvest	3rd harvest	4th harvest	Mean (T)	1st harvest	2nd harvest	3rd harvest	4th harvest	Mean (T)
Control	131	132	132	128	**131 b**	35.3	37.6	36.7	22.87	**33 e**
10ppm GA_3	132	133	134	130	**133ab**	38.4	39.5	40.6	26.30	**36 c**
20ppm GA_3	133	134	135	131	**133ab**	40.2	42.6	44.0	29.07	**39ab**
10ppm 2,4-D	134	135	135	132	**134ab**	40.3	43.2	45.6	25.40	**39 b**
15ppm 2,4-D	135	136	136	133	**135 a**	41.4	44.4	46.8	27.40	**40 a**
2%Calcium nitrate+ 0.1% Boric acid	131	132	132	130	**131ab**	35.6	36.2	38.1	27.17	**34de**
10ppm Cobalt Sulfate	132	133	134	130	**132ab**	36.3	37.6	38.7	26.80	**35 d**
20ppm Cobalt Sulfate	133	135	135	131	**134ab**	36.7	37.4	38.5	22.80	**34de**
Mean (harvest)	**133ab**	**134 a**	**134 a**	**131 b**		**38.0 c**	**39.8 b**	**41.1 a**	**26.0 d**	
	Season, 2017									
Control	133.0	135.0	135.4	131.3	**134 b**	36.3	37.3	35.4	25.3	**33.6 e**
10ppm GA_3	135.0	136.0	136.7	134.7	**136ab**	39.2	40.7	42.3	29.6	**38.0 c**
20ppm GA_3	136.0	136.7	137.0	134.4	**136ab**	43.3	45.0	47.3	33.7	**42ab**
10ppm 2,4-D	137.0	139.0	139.4	135.3	**138ab**	43.6	44.7	47.0	29.6	**41.2 b**
15ppm 2,4-D	139.0	141.0	141.0	136.7	**139 a**	45.7	47.0	49.3	29.7	**42.9 a**
2%Calcium nitrate+ 0.1% Boric acid	134.0	137.0	137.3	131.3	**135 b**	37.1	38.7	41.6	29.3	**36.7 d**
10ppm Cobalt Sulfate	136.0	138.0	134.0	134.3	**136ab**	39.1	39.7	42.0	28.7	**37cd**
20ppm Cobalt Sulfate	135.0	136.0	135.0	132.7	**135 b**	40.1	38.6	41.3	25.3	**36.3 d**
Mean (harvest)	**136ab**	**137 a**	**137 a**	**134 b**		**40.6 c**	**41.5 b**	**43.3 a**	**28.9 d**	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

These results are in conformity with the findings of the Ladaniya, (1997) in Nagpur mandarin who stated that GA3 treated fruits had higher peel puncture resistance and Kaur, et al., (2008) observed the similar trends in the plum. In all the treatments the firmness was found to decrease

Table 2: Peel thickness (mm) and Peel firmness (mm) as affected by some treatments on tree storage of Balady mandarin.

Treatments	Peel thickness (mm) 1st harvest	2nd harvest	3rd harvest	4th harvest	Mean (T)	Peel firmness (mm) 1st harvest	2nd harvest	3rd harvest	4th harvest	Mean (T)
Season, 2016										
Control	3.82	3.61	3.59	3.36	**3.6 d**	4.77	4.51	4.16	3.51	**4.2 f**
10ppm GA_3	4.07	3.72	3.68	3.38	**3.71d**	5.12	4.93	4.72	4.50	**4.8 b**
20ppm GA_3	4.11	3.81	3.70	3.42	**3.8 c**	5.32	5.03	4.84	4.72	**5.0 a**
10ppm 2,4-D	4.11	3.92	3.80	3.51	**3.8bc**	4.83	4.65	4.34	4.40	**4. 6 d**
15ppm 2,4-D	4.16	4.01	3.92	3.78	**4 ab**	5.02	4.82	4.50	4.39	**4.7 c**
2%Calcium nitrate+ 0.1% Boric acid	4.21	4.11	3.96	3.93	**4.1 a**	4.91	4.70	4.64	4.42	**4.7 c**
10ppm Cobalt Sulfate	3.98	3.65	3.62	3.59	**3.7cd**	4.69	4.52	4.41	4.20	**4.5 e**
20ppm Cobalt Sulfate	4.13	3.86	3.78	3.66	**3.9bc**	4.92	4.73	4.55	4.32	**4.6cd**
Mean (harvest)	**4.1a**	**3.8b**	**3.8 b**	**3.6 c**		**5.0 a**	**4.7 b**	**4.5 c**	**4.3 d**	
Season, 2017										
Control	4.05	3.65	3.61	3.50	**3.7 e**	4.59	4.40	4.22	3.43	**4.2 g**
10ppm GA_3	4.13	3.64	3.59	3.51	**3.7de**	5.33	4.98	4.82	4.62	**4.9b**
20ppm GA_3	4.22	3.83	3.68	3.60	**3.8bc**	5.36	5.22	5.09	4.81	**5.1 a**
10ppm 2,4-D	4.31	4.11	3.90	3.78	**4.0 a**	4.70	4.55	4.30	4.11	**4.4 f**
15ppm 2,4-D	4.33	3.88	3.70	3.65	**3.9 b**	4.75	4.62	4.51	4.23	**4.5 e**
2%Calcium nitrate+ 0.1% Boric acid	4.32	3.98	3.92	3.88	**4.0 a**	5.44	4.31	5.11	4.63	**4.9 c**
10ppm Cobalt Sulfate	4.22	4.06	3.93	3.87	**4.02**	4.80	4.68	4.54	4.32	**4.6 d**
20ppm Cobalt Sulfate	4.11	3.80	3.70	3.57	**3.8cd**	4.67	4.50	4.42	4.21	**4.5 f**
Mean (harvest)	**4.21a**	**3.9 b**	**3.8 c**	**3.7 d**		**5.0 a**	**4.7 b**	**4.6c**	**4.3 d**	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

with ripening advancement. This might be due to cell wall loosening of the fruit. The pro-pectin, which acts as a cementing material for binding the cellulose and hemicelluloses is converted to soluble pectin. As a result it loosens the cell wall's binding force during ripening (Rana, 2006).Also, GA3 + 2, 4-D maintained peel puncture resistance when applied in pre- harvest (El-

Otmani, et al., 1990) on Clementine mandarin and orange ,(El-Zeftawi,1980b) on grapefruit. In addition, improvement in fruit physical characters by calcium sprays in the present study led to specially an increase in peel thickness and decrease in rind ageing, softening and creasing as obtained by Sayed, et al., (2004) working on grapefruit and El-Hilali, et al., (2004) working on mandarin. Also, Storey, et al., (2005) reported rind fruit disorders as a result of calcium deficiency. Calcium is involved in cell wall membrane metabolism and it contributes to the maintenance of configuration of specific enzymes (Jones and Lunt, 1967). Addition of calcium improves rigidity of cell walls and obstructs enzymes such as polygalacturonase from reaching their active sites (John, 1987), thereby retarding tissue softening and delaying ripening. Repeated sprays of calcium solutions increased the proportion of unaffected navel orange fruit with albedo breakdown (Treeby and Storey, 2002). On the other hand, Wahdan, (2011) sprayed "Succary Abiad" mangoes by cobalt sulphate at concentrations of 100, 200 and 300 ppm at 30 days after full bloom. It increased fruit weight volume and pulp weight. Fruit firmness was increased by spraying cobalt sulfate at 300 ppm.

TSS/Acid ratio: TSS/Acid ratio is an important characteristic for fruits exportation. It is noticed from (Table 3) that, TSS/ Acid ratio increased by increasing harvest period up to the 4th harvest. On the other hand, control treatment could earlier the over ripe date by increasing fruit TSS/ Acid ratio as compared with other treatments, while other tested treatments delay the over ripe date especially2,4-D and GA3treatments. In more details, on-tree storage the highest values of fruit TSS/ Acid ratio were obtained by control (12.2, 12.57) While, the minimum values were obtained by 15 ppm 2, 4-D (10.16, 10.25) and by 20ppm GA3 (10.45, 11.06) in the first and second seasons, respectively. Meanwhile, the differences between the other treatments were in between during two seasons. These results substantiate the earlier reports of Kaur et al., (2008) in plum and Ladaniya, (1997) in Nagpur mandarin who reported an increase in TSS/acid ratio with GA3 treatments. It was obvious that the TSS content increased while juice acidity decreased resulting in an increase in the TSS/acid ratio during holding of fruit on the tree. The increased TSS content could have been due to further synthesis and accumulation of photosynthates in the fruits on the tree (Murata, 1977). Also, GA3 applications were found to be effective (El-Zeftawi, 1980 a, b). Differences between the research results are due to variable factors of growth regulators according to the citrus species and the application time especially of GA3 (Cogins, 1981). In addition, the decrease in TSS/acid ratio with calcium application can be attributed to lower gap between the TSS and acid level of the fruits. The present results relating to calcium treatments corroborate the previous findings of Brahmachari, et al., 1997 in guava. The extension of harvest period at each interval resulted in a general increase in TSS/acid ratio. This increase can be attributed to regular increase of total sugars and decrease of acidity as the natural phenomenon of ripening. Similar increase in TSS/acid ratio with delayed harvesting was observed by Ladaniya (1997), though the increase was non-significant. On the other side, foliar

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applications of cobalt sulphate have been resulted in increasing fruit set and retention, fruit yield, weight, size and TSS: acid ratio and total sugars in many mango cultivars (Singh, and Agrez, 2002; Wahdan, 2011).

Table 3: TSS / Acid and Vitamin C as affected by some treatments on tree storage of Balady mandarin.

Treatments	TSS / Acid					Vitamin C (mg/100 ml)				
	1st harvest	2nd harvest	3rd harvest	4th harvest	Mean (T)	1st harvest	2nd harvest	3rd harvest	4th harvest	Mean (T)
Season, 2016										
Control	10.2	12.37	12.70	13.53	**12.2 a**	22.5	21.4	18.3	13.8	**19.0 f**
10ppm GA_3	10.0	10.40	11.00	11.31	**10.7 c**	27.3	26.1	22.3	18.3	**24 ab**
20ppm GA_3	9.50	10.19	10.67	11.44	**10.5 c**	28.4	26.7	22.9	19.17	**24.3 a**
10ppm 2,4-D	10.0	11.93	12.00	12.88	**12 ab**	25.3	23.6	19.3	16.1	**21 de**
15ppm 2,4-D	9.18	9.80	10.50	11.15	**10.2 c**	26.6	24.8	20.2	17.8	**22.4 c**
2%Calcium nitrate+ 0.1% Boric acid	10.0	11.96	12.50	13.10	**12 ab**	23.7	22.3	19.2	15.7	**20.2 e**
10ppm Cobalt Sulfate	9.42	11.55	12.00	12.73	**11.4 b**	27.2	25.9	21.3	16.7	**23 bc**
20ppm Cobalt Sulfate	9.90	12.12	12.60	12.82	**12 ab**	26.4	25.3	21.7	14.1	**22 cd**
Mean (harvest)	**9.78 c**	**11.3 b**	**11.8 b**	**12. a**		**25.9 a**	**24.5 b**	**20.7c**	**16.5 d**	
Season, 2017										
Control	10.81	12.67	13.00	13.80	**12.6 a**	24.4	23.6	20.1	16.4	**21.1 e**
10ppm GA_3	10.76	11.00	11.20	12.14	**11.3 c**	26.9	26.0	24.9	22.0	**25.0 c**
20ppm GA_3	10.33	10.81	11.33	11.76	**11.1 c**	29.3	28.0	27.4	23.4	**27.0a**
10ppm 2,4-D	10.50	12.12	12.33	13.30	**12. ab**	25.7	25.0	23.4	19.4	**23.4 d**
15ppm 2,4-D	9.00	10.00	10.50	11.50	**10.3 d**	27.4	26.0	24.3	20.6	**24.6c**
2%Calcium nitrate+ 0.1% Boric acid	10.33	12.31	12.50	13.67	**12 ab**	28.5	27.0	25.0	20.4	**25 bc**
10ppm Cobalt Sulfate	10.00	12.31	12.60	13.21	**12.0 b**	27.4	27.0	26.2	20.3	**25 bc**
20ppm Cobalt Sulfate	10.33	12.34	12.80	13.45	**12 ab**	29.0	27.0	26.1	21.3	**25.9b**
Mean (harvest)	**10.3 c**	**11.7 b**	**12.03**	**12.9 a**		**27.3 a**	**26.2 b**	**24.7c**	**20.5 d**	

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

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Vitamin C: Higher vitamin C content imparts higher nutritive value to fruits. Data in (Table 3) showed that the vitamin C content decreased with the advancement of storage of fruits on tree in all treatments. However, more pronounced decrease was found in the non-treated fruits (control). However, the content of vitamin C was recorded higher in the GA3 treated fruits than in non-treated. The maximum vitamin C content was obtained with GA3 at 20ppm (24.29, 27.03 mg/100 ml) followed by cobalt sulfate at 10 ppm (22.78, 25.23 mg/100) as against control (19, 21.13 mg/100 ml) in the first and second seasons, respectively. Also, the changes of V.C have fluctuated during the two seasons. These results were in line with the findings of Sindhu and Sighrot,(1993) who reported that, maximum ascorbic acid content in GA3 treated fruits .A decrease in ascorbic acid could be due to enzymatic loss of L-ascorbic acid where it is converted to 2-3-dioxy–L-gluconic acid (Mapson, 1970). Few studies indicated that, GA3 applications were found to be effective (El-Zeftawi, 1980a, b). Differences between the research results are due to variable factors of growth regulators according to the citrus species and the application time especially of GA3 (Cogins, 1981). Moreover, Chundawat and Randhawa (1973) reported that vitamin C content increased with spray of 2, 4-D in Duncan cultivar of grapefruit. Immature citrus fruits have the highest amount of ascorbic acid whereas; ripened fruit have the least as reported by (Nagy, 1980).

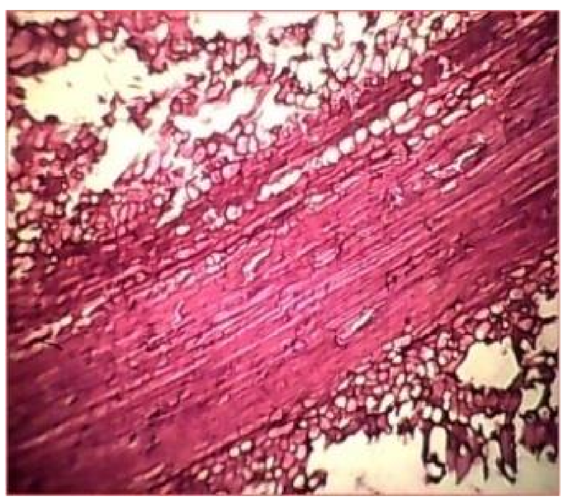

Fig. 4: Longitudinal section of fixed fruit

Anatomy study: Citrus fruits were characterized by having two abscission zones; the first (AZ-A), between the branch and fruit peduncle, is visible morphologically, however histological, is detectable only at early stages of fruit development. The second abscission zone (AZ-C), in calyx, is active throughout the year and detectable only by light microscope (Burns, 1998;

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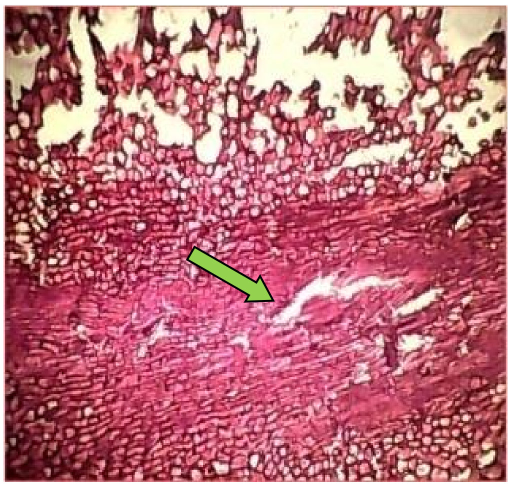
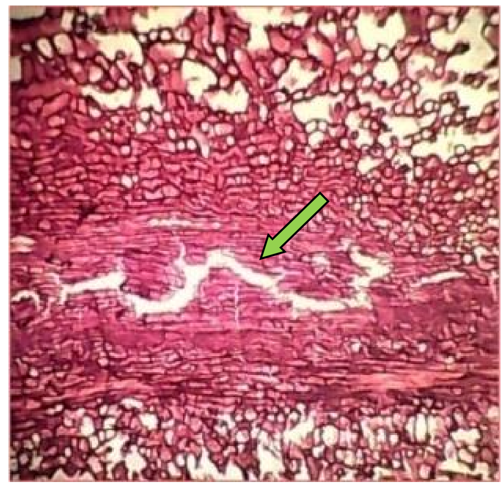
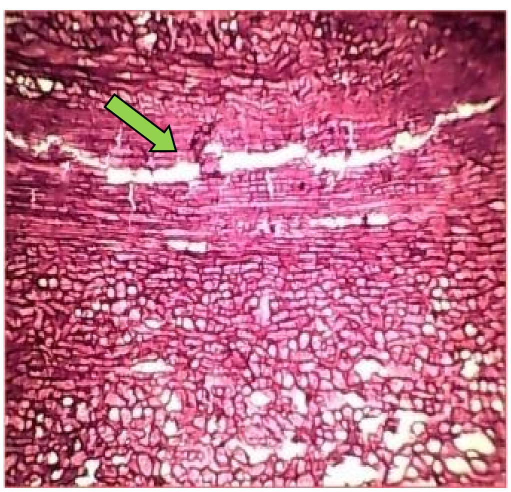
Iglesias, et al., 2007). Longitudinal section of fixed fruit was shown in (Figure 4), longitudinal section of abscission fruit were shown in (Figure 5 A, B, C and D). Its noticed that, abscission zone (AZ-C) have small compact cells with no extracellular spaces and swollen cell walls, underwent considerable anatomical changes with time, such as increasing in cell wall thickness, changes in cell shape, incidence of plasmolysis at the final stage and formation of cracks among them which lead to fruit abscission at zone C (Zanchin, et al., 1995).



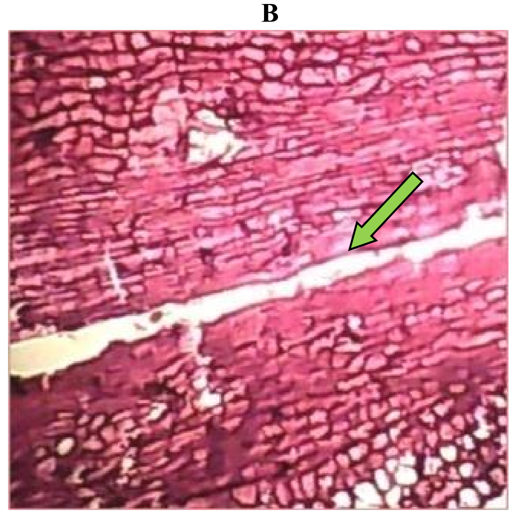
A



B



C



D

(Figure 5A, B, C and D) longitudinal section of abscission fruit, arrow refer to abscission zone (AZ-C).

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Generally, the cell separation process does not involve the entire AZ. The cells within the AZ that are involved in the abscission process by rapid reduction in cell integrity (Sexton and Roberts, 1982) have been identified as separation layer (Roberts, et al., 2000). Our structural Microscopic observations showed that cells in the abscission zones were very compact with no extracellular spaces which are smaller than neighboring cells (fig. 5A, B, C and D). In the final stages of fruit development we observed sever plasmolysis (fig.5C), and after that deep cracks were visible which led to fruit abscission (fig. D). In this respect, Weis, et al., (1991) pointed to plasmolysis occurance as a natural phenomon during abscission in olive.

Economic side: Economic side for citrus fruit; is a concept varies according to the final use of the fruit and at what point from orchard to consumer the fruit is evaluated. For the fruit packing industry; fruits that are of uniform size, free of blemishes offer good market is good quality. The harvested fresh fruit requires being high TSS/Acid ratio and excellent color, shape and firmness; whereas, requirement of juice industry is to obtain fruits with high juice and sugar content. Concerning the grower, any fruit that can be sold at a reasonably good price it would be good economically. Therefore, when the domestic market is saturated by mandarin fruits; store the fruit on the tree for a certain period with maintaining the quality of the fruit as possible maximizes the profitability of the grower.

CONCLUSION

The prolongation of harvesting period in Balady mandarin can be achieved successfully without affecting its fruit quality. Maximum good quality of fruits could be attained until the beginning of March with foliar application at color break with 2, 4- D at 15 ppm.

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