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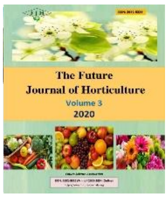

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RAISING AND IMPROVING THE PRODUCTIVITY OF THE WASHINGTON NAVEL ORANGE TREES PLANTED IN THE NEWLY RECLAIMED LANDS BY FOLIAR SPRAY WITH GIBBERELLIC ACID

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ABSTRACT: Fruit drop and quality are the most important factors in Washington navel orange production and exporting potential. This study was done at a private farm located in Sadat district, throughout the two seasons of 2020 and 2021 on Washington navel orange trees 20 years old was planted in sand soil. Three different concentrations (0.0, 5.0, 15.0 and 25.0 ppm) of Gibberellic acid (GA_3) were applied as foliar spray at full bloom stage of orange cultivars. To determine the association of GA3 with fruit set and fruit drop. The obtained results showed that GA_3 sprays at 25 ppm were more effective compared with other treatments and control in term of fruit set, retention, and yield as number or weight (Kg) /tree, improved the yield as well as the physical and chemical fruit characteristics, decreased drop. It might be recommended that foliar spraying with 25 ppm GA_3 gave the best values of yield (kg) /tree, fruit physical and chemical properties.

Key words: Gibberellic acid, Foliar application, Washington navel orange, Fruit set, June drop, Fruit retention.

INTRODUCTION

Washington navel orange (*Citrus sinensis L. Osbeck*) ranked first among the species of genus citrus in Egypt. It accounts for approximately 35% of total citrus cultivated area, with an acreage of approximately 181091 feddans and a total production of 1663284 tonnes/year (**Ministry of Agriculture, Egypt 2015**). Citrus, in general, suffers from quality fruit disorders such as creasing, splitting, puffing, and peel pitting, which all have an impact on marketing and keeping quality, such as Navel orange. In Egypt, it is mostly consumed fresh, either in the local market or for export **(El-Khayat, 2020)**. Foliar applications of plant growth regulators are the most powerful tools for influencing tree growth, blooms, yield, and fruit quality traits **(Ashraf et al., 2013)**. Gibberellins have a wide range of applications in citrus production; GA_3 has been used for flower reduction, improved fruitlet setting, fruit superiority enhancement, and enhance ripening control **(Agustí and Almela, 1991)**. GA_3 has been shown to slow fruit ripening and postpone fruit senescence. It has been shown to be effective in delaying citrus fruit maturation and quality issues like rind softening, creasing, peel pitting, and puffing **(Hifny *et al.*, 2017).** Many researchers have mentioned yield and fruit quality of fruit crops, such as **(Morton, 1987)** who assert that the use of GA3 at full bloom or the early stages of fruit development has greatly enhanced the amount of Washington navel fruits collected. Furthermore, positive effects of GA_3 were supported by **(Agusti *et al.*, 1982; Abd El-Migeed, 2002; Sayed *et al.*, 2004; Saleem *et al.*, 2008; Ullah *et al.*, 2014 and EL-Gioushy *et al.*, 2018)** on oranges. The goal of this study was to evaluate the effects of applying different concentrations of GA3 as a foliar spray to 'Washington' navel orange trees.

MARTIAL AND METHODS

This study was done during two successive seasons of 2020 and 2021 on grown Washington navel orange trees 20 years old in a private farm located in Sadat district, Minufiya Governorate Egypt. The trees were planted in sandy soil at 4x5 meters apart under a drip irrigation system using Nile water.

Foliar application of Growth Regulator; The aqueous solution of 0.0 ppm, 5.0 ppm, 15.0 ppm and 25.0 ppm of GA_3 was prepared according to the standard formula (0.0 ppm 100 liter of water without GA_3), (0.5 g GA_3 dissolved in 100 liter of water = 5 ppm), (1.5 g GA_3 dissolved in 100 liter of water = 15 ppm) and (2.5 g GA_3 dissolved in 100 liter of water = 25 ppm). Each treatment was replicated three times, one tree per each; four GA_3 concentrations were sprayed at full bloom stage.

Before the foliar application of GA_3, four branches of almost same length, diameter and vigor were tagged in each direction. 24 hours after foliar application of growth regulator, number of flowers branch^{-1}were counted while % fruit set branch^{-1} was determined by the following procedure:

Fruit set percentage (%) = {(Number of fruit set/branch)/ (Number of flowers/branch)} × 100

Similarly, % fruit drop, %June drop and % pre-harvest fruit drop was found out through this procedure:

Fruit drop percentage (%) = {(Number of fruits dropped/branch)/ (Number of fruit set/branch)} × 100

June drop percentage (%) = {(Number of fruits dropped at the end of June/branch)/ (Number of fruits before June/branch)} × 100

Preharvest fruit drop percentage (%) = {(Number of fruits dropped at the time of harvest/tree)/ (Number of fruits before harvest/tree)} × 100

Fruit weight and yield/tree recorded after fruit harvest.

Statistical analysis

Data recorded in all seasons were subjected to analysis of variance according to **Snedecor and Cochran (1990)** and L.S.D test was used to differentiate means using the MSTAT-C Statistical Package **(MSTAT-C, 1990)**.

RESULTS AND DISCUSSION

Fruit set percentage

Data from (Table 1) clearly showed that GA_3 at 25 ppm sprays greatly enhanced fruit set in both seasons. The trees that received GA_3 sprays produced the highest fruit set, whereas the control trees produced the lowest. The results revealed that spraying GA_3 at 25 ppm has a positive effect on increasing fruit set than control. Numerous researchers have noted that exogenous treatment of gibberellins increases fruit set of sweet orange, (**Ullah *et al*., 2014)** The results obtained are consistent with those discovered by **(Agusti *et al*., 1982)** who stated that GA_3 sprays at petal fall improve fruit set of Washington navel orange tree. The data's analysis revealed in (Table1) notable variations between different concentrations of GA_3, cultivars, and their interaction for fruit set and % fruit set/branch. The mean number of fruits/branch (13.79) were obtained with the foliar application of 5 ppm GA_3 and then 15 ppm (13.52) there is no significant difference between them as well as show a significantly different from the other treatments. The control treatment shows less means number of fruits (8.81).

Table 1. Fruit set, fruit drop and yield of Washington navel orange as affected by GA_3 treatment

GA_3 (Conc.)	FS	FS%	FD%	JD%	PHFD %	FW (g)	YT (kg)
				2020			
G0	8.09 b	17.29 b	56.94 b	31.7 a	56.94 a	317.58 c	134.13 b
G1	13.49 a	18.88 b	54.99 b	15.01 c	49.47 c	322.99 b	137.37 a
G2	13.15 a	27.76 a	68.67 a	18.51 b	54.57 b	326.13 b	132.53b
G3	9.08 b	22.31 a	49.32 c	9.49 d	49.52 c	339.33 a	136.77 a
				2021			
G0	8.81b	19.55 b	58.04 b	30.99 a	55.53 a	322.02 c	137.66 b
G1	14.09a	19.78 b	55.47 b	14.91 c	47.23 c	332.78 b	136.30 b
G2	13.89a	28.07 a	69.46 a	19.48 b	53.25 b	335.22 b	136.84 b
G3	10.14b	24.98 a	51.41 c	10.21 d	47.33 c	342.54 a	141.60 a

FS (fruit set branch^{-1}), % FS (% fruit set branch-1), % FD (%fruit drop branch^{-1}), %JD (%June drop branch^{-1}), % PHFD (% pre-harvest fruit drop branch^{-1}), FWt. (Fruit weight) and Yt^{-1} (Yield tree^{-1})

It's possible that GA3's increased availability of nutrients from leaves responsible for the increase in fruit set and % fruit set, but it's also possible that the ability of a particular variety's genetics to set either a high or low %of fruits is to blame. In this study, all GA_3 treatments showed a significant increase in fruit set of Washington navel orange in comparison to control. These findings agree with (**EL-Gioushy *et al.*, 2018; El-Khayat, 2020 and Elmenofy *et al.*, 2021)** They stated that the enhanced availability of nutrients from leaves was what caused the rise in fruit set following GA_3 application and some growth regulators. While a only one spray of GA_3 at the petal fall to the whole tree increase fruit set **(Agusti *et al.*, 1982)**, similarly a GA_3 spray of (10 ppm) in pear at anthesis led to a higher set **(Herrero, 1984)**. These results are consistent with those of **El-Khayat (2020)** who observed the maximum fruit set in with gibberellic acid (GA_3) at 30ppm Salicylic acid ،ascorbic acid and Citric acid) each at 400 ppm treated trees of increased fruit set in orange., similarly uses GA_3 at 30 ppm and Chitosan at 2g or 4g had more impacts on fruit set. **(Mohamed and Ahmed, 2019).**

Fruit retention percentage

Fruit drop rates, June drop rates, and pre-harvest drop rates are all calculated per branch. According to the analysis, foliar GA_3 spray had a significant impact on fruit drop, June drop, and pre-harvest drop branch percentages. Considering the information provided in (Table 1) In comparison to the other treatments, the foliar spray of 15 ppm GA_3 resulted in a greater mean of fruit drop (69.07), which was statistically different than control and 5 ppm treatments (57.49 and 55.23) While the minimum fruit drop percentage (50.37) was attained using 25 ppm GA_3, The least June drop (9.85) was produced by trees treated with 25 ppm GA_3 sprays, whereas the largest June drop (31.35) was recorded in the control group, than 15 ppm (18.99). As a result, trees regarded to be controls showed higher mean percent pre-harvest fruit drop (56.24) then with 15 ppm (53.91), but trees treated with 5 ppm and 25 ppm GA_3 sprays showed lower mean % pre-harvest fruit drop (48.35 and 48.43), respectively.

For tree-1 yield and fruit weight, the analysis showed that GA_3 treatments, and its interaction were different at ($p<0.05$). However, the control treatment resulted in the lowest mean fruit weight, whereas the administration of 25 ppm GA_3 resulted in the highest mean fruit weight (340.94 g), followed by 15 ppm (330.68 g), and then by 5 ppm (327.89 g) (319.80 g). Similar to this, using 25 parts per million GA_3 produced the highest result (193.18 kg), followed by 5 parts per million (136.83 kg), while 15 parts per million and control produced the lowest values (134.68 and 135.89 Kg).

These differences between treatments towards % fruit drop, %June drop and % preharvest drop are possibly the result of the fruit response to different treatments and lost due to changes in weather. This agree with that of **Yamamura *et al.* (1989)** that the application of GA_3 reduced fruit drop in 'Saijo' and 'Fuyu" cultivars of persimmon. Sprayed GA_3 was helpful in preventing fruit drop in Balady mandarin **(El sayed, 2021)** sweet orange **(Liao *et al.*, 2006)**. The use of plant growth regulators to change different plants mechanisms is very popular in various crops around the world, including citrus. However, the dosage and timing remain a limiting factor in outcomes.

Leaf Mineral Content

Table (2) shows that GA_3 increased N content in the leaves more than control. This effect was more noticeable in 2021. Trees sprayed with 25 ppm GA_3 had the highest leaf N content. In terms of P content in the leaves, GA_3 sprays slightly increased its values compared to the control. However, no notable change in P leaf content were found between treatments in either season. GA_3 sprays at a (25 ppm) increased K content in the leaves slightly and insignificantly more than the control enhanced the nutrition of trees in terms of N, K, and Zn leaves contents. this results are in agreement with those maintained by **(Dawood *et al*, 2001 and El sayed, 2021)** who found that GA_3 sprays enhanced leaf N content in Balady mandarin. Also, with those mentioned by **(Sayed *et al.*, 2004)** who observed that sprayed of GA_3 having a positive impact on the mineral content of orange tree leaves.

Table 2. Effect of GA_3 on N, P, and k contents of Washington navel orange leaves in the two seasons

GA_3 (Conc.)	N %	P %	K %	N %	P %	K %
		2020			2021	
G0	2.14 a	0.13 a	1.20 a	2.11 b	0.14 a	1.17 b
G1	2.20 a	0.16 a	1.19 a	2.28 a	0.15 a	1.09 b
G2	2.25 a	0.15 a	1.26 a	2.33 a	0.16 a	1.20 b
G3	2.29 a	0.14 a	1.20 a	2.30 a	0.15 a	1.35 a

Physical properties

Table 3 shows that using GA_3 at 25 ppm during both seasons yielded the highest values for fruit weight, size, peel weight, and pulp weight. The control treatment yielded the highest specific gravity values. This is due to a reduction in fruit weight and size when especially in comparison to all treatments. The increase in cell division elongation effected by the plant's hormones may be responsible for the larger fruit. **(Ranjan *et al.*, 2003 and Hifny *et al.*, 2017)**. said that applying NAA and GA3 boosted fruit weight and yield by lengthening cells by enlarging vacuoles and loosening cell walls after boosting wall flexibility.

Juice volume (cm^3)

Data in Table 3 demonstrated that utilising GA_3 as compared to control in both seasons significantly increased juice volume. Using GA_3 at 25 ppm, the maximum juice volume was obtained. The results obtained agree with **Baghdady *et al.* (2014)** in Valencia orange trees sprayed with GA3 at full bloom stage, and that this resulted in a greater yield of fruit juice than the control trees. same **Farag and Nagy (2012)** in Washington naval orange.

Table 3. Effect of foliar spraying with GA_3 on some fruit physical characteristics of Washington navel orange cultivar in two seasons

Character / GA_3 (Conc.)	Fruit size (cm^3)	Specific gravity (g/cm^3)	Fruit Peel weigh (g)	Fruit pulp weight (g)	Juice volume (cm^3)	Fruit length (cm)	Fruit diameter (cm)
				2020			
G0	346.25 d	0.92 a	60.87 d	256.71 c	110.75 d	8.70 d	8.03 d
G1	378.8 c	0.86 b	64.19 b	258.8 c	126.39 c	9.20 c	8.43 c
G2	385.4 b	0.85 b	63.46 bc	262.67 b	132.08 b	9.62 b	8.69 b
G3	391.81 a	0.85 b	66.34 a	272.99 a	159.09 a	9.78ab	8.95 a
				2021			
G0	351.99 d	0.91 a	64.11 b	257.91 c	116.99 d	8.93 c	7.99 c
G1	382.98 c	0.85 b	63.77 b	269.01 b	137.02 c	9.52 b	8.47 b
G2	394.33 b	0.86 b	64.16 b	271.06 b	140.05 b	9.84b	8.78b
G3	398.88 a	0.86 b	66.31 a	276.23 a	168.07 a	10.54 a	9.34 a

Fruit length and diameter

Regarding how different GA_3 treatments affected the diameter of polar and equatorial fruit, (Table 3) clearly showed that these treatments considerably enhanced fruit length and diameter compared to untreated plants. However, in the two time periods under study, GA_3 at 15 ppm and 25 ppm greatly raised the highest polar and equatorial diameters then control. This agrees with the observation by **Abd El-Rahman *et al.*, 2012 and Ghazzawy, 2013** found that this might to ability of GA_3 in the division and elongation of the fruit cells. **(Stern *et al.*, 2007)** find GA_3 increase in fruit volume.

Fruit biochemical characteristics

Total soluble solids (TSS), total acidity %, and several fruit biochemical properties as a result of GA_3 foliar spraying According to data in Table 4, every GA_3 application significantly increased TSS (%) as compared to the control during the two seasons. The highest TSS percentage values were achieved when trees were treated with GA_3 at a concentration of 25 ppm, followed by GA_3 at 15 ppm in descending order. All concentrations tested caused a reduction in total acidity percentage in compared to the con. When compared to untreated plants (control) and other applications, GA_3 with a 25 ppm application recorded the lowest total acidity % in Washington navel orange fruits. The results agreed with **Farag and Nagy (2012)** noted that sprayed apples with GA_3 (25 ppm) at full bloom led to decreased total acidity.

Orange fruit ripened earlier than that of untreated plants, which may be the cause of the orange fruit's considerable drop in overall acidity **(Hifny *et al.*, 2009)**. Table (4) demonstrated that, when compared to untreated plants, the TSS/acid ratio dramatically enhanced by raising GA_3 rates in the two seasons. After spraying Washington navel orange trees with GA_3 at 25 ppm, the TSS/Acid ratio was at its highest point and no discernible difference was found between these treatments and GA_3 treatments. These results are in contract with **Hikal (2013)** on Washington navel oranges, they discovered that foliar spraying the trees with GA_3 at 20 ppm and Amcotone increased the TSS/acid ratio of fruits and reducing total acidity. Data in (Table 4) demonstrated that, in the two seasons under study, spraying Washington navel orange trees with GA3 at various dosages boosted Vitamin C in comparison control. The highest vitamin C values were achieved when trees were treated with GA_3 at a concentration of 25 ppm. The results agreed with **(Hikal, 2013 and Hifny *et al.*, 2017).**

We can come to conclusion that foliar application of Washington navel orange with GA_3 at different concentrations significantly improved the yield as well as the physical and chemical fruit characteristics, and decreased drop. The best foliar application was obtained with GA_3 at 25 ppm in comparison to control and other application.

Table 4. Effect of foliar spraying with GA_3 set on some fruit chemical characteristics of Washington navel orange cultivar in two seasons

Character / GA_3 (Conc.)	TSS (%)	Total acidity (%)	TSS/ Acid ratio	V.C (mg/100ml) of fruit juice
		2020		
G0	10.18 c	1.13 a	9.01 c	45.99 c
G1	11.19 b	0.90 b	12.43 a	50.02 b
G2	11.26 b	1.01 a	11.15 b	53.42 a
G3	12.53 a	1.04 a	12.05 a	55.33 a
		2021		
G0	11.56 c	1.15 a	10.05 b	53.21 c
G1	11.91 c	0.92 b	12.95 b	57.98 b
G2	13.54 b	1.05 a	12.90 a	59.53 b
G3	14.25 a	1.11 a	12.84 a	61.43 a

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RESEARCH ARTICLE

Raising and improving the productivity of the Washington navel orange trees planted in the newly reclaimed lands by foliar spray with gibberellic acid

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