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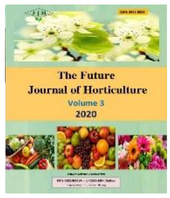

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IMPROVING YIELD AND FRUIT QUALITY OF WASHINGTON NAVEL ORANGE TREES GROWN UNDER SANDY SOIL CONDITIONS BY GA_3 SPRAYS

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ABSTRACT: Fruit drop and fruit quality are the most values in Washington navel orange since they are playing the main role in production and exporting potential. The current study was carried out during the two successive seasons of 2018 and 2019 on 20 years old of Washington navel orange trees grown in sandy soil in a private orchard located at Sadat district, Minufiya Governorate Egypt. To determine the association of Gibberellic acid with fruit set and fruit drop of Washington navel orange. 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 Washington navel orange cultivars. Fruit set as well as fruit drop at different developmental stages of fruit were calculated. 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, fruit retention and yield as fruit number or weight (Kg) per tree, fruit retention, decreased fruit drop and subsequently improved the yield as well as the physical and chemical fruit characteristics. It might be recommended that foliar spraying Washington navel orange trees with 25 ppm GA_3 one week after fruit set gave the highest 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) is one of the most important species in the genus citrus. In Egypt Washington navel orange ranked first among the species of citrus. It occupies about 35 % of the total cultivated area of citrus, since its acreage reached about 181091 feddans with total production of 1663284 tons per year. According to the last census, issued by **Ministry of Agriculture, Egypt (2015)**. Yields are fluctuated in several zones because of need useful pollen, once in a while create suitable ovules and furthermore, are poorly parthenocarpic **(Krezdorn, 1965)**. Flower and fruitlet drop of navel orange happened in three stages and sum to a total 91%, giving a fruit set of 9% **(Villafane *et al.*, 1989)**. Gibberellins have a board series of usages in citriculture; GA_3 have been used in citrus production with several purposes including flower reduction, improved fruitlet setting, enhancement of fruit superiority and improved ripening control **(Agustí and Almela, 1991)**. The treatment of GA_3 rapidly after flowering at concentrations ranged 10 and 15 mg/l. can affect in delayed abscission and improved fruitlet set, mostly in Clementine tangerines **(El-Otmani, 1992)**. Small fruit size and creasing are the main limiting factors in sales of ‘Washington’ navel orange (*Citrus sinensis* L. Osb.). Synthetic auxin sprays, applied for increasing fruit size are a common cultural practice among citrus growers throughout the world and their effects have been reviewed **(Rabe, 2000)**. Drop exists extensively in many Egyptian orchards, whereas, Washington navel orange is a parthenocarpic cultivar thus decrease in yield and fruit quality can affect it. Yield and fruit quality of fruit crops were mentioned by many investigators as **(Morton, 1987)** who found that, GA_3 whether, applied at full bloom or small fruit stage, has significantly increased the number of Washington navel harvested fruits. Also, the beneficial effects of GA_3 were supported by **(Agusti *et al.*, 1982; Abd El-Migeed, 2002 and Sayed *et al.*, 2004)** on oranges, **(El-Sese, 2005)** on mandarin.

Fruit production is entirely dependent on good fruit set, and successful retention of fruit on tree up to fruit maturity. Keeping this fact in mind various research studies have been conducted to enhance flower initiation and fruit set in various fruit trees including sweet oranges. A single GA_3 spray of 5 mg L^{-1} followed by girdling at petal-fall to the entire tree enhanced initial set in the 'Navelate' sweet orange (*Citrus sinensis* L.) by increasing the final yield due to increase in number of fruits but having no effect on fruit size **(Agusti, 2000)**. **Garcia-Martinez and Garcia-papi (1979)** reported that GA_3 application increased fruit set in Clementine mandarin due to an increased availability of nutrients from the leaves. Spraying GA_3 (5–200 mg L^{-1}) to entire trees of cultivar 'Fino' proved to be more efficient in increasing the number of fruits tree-1 and finally an increase in the commercial yield. GA_3 application directly to the developing apex near to flower differentiation reduced the number of flowers panicle^{-1} by 25–35% in loquat and without modifying the morphological characteristics of the panicle **(Reig *et al*., 2011)**. GA_3 (45 mg L^{-1}) treated trees of Blood Red sweet orange showed a significant increase in term of fruit set and final yield as compared to control treatment **(Saleem *et al*., 2008)**. Late fruit growth and final fruit size were increased by the application of the synthetic auxin 2,4,5- trichlorophenoxy acetic acid, which had a specific effect on the enlargement of the juice vesicles **(Guardiola *et al*., 1993)**. Application of GA_3 (10 ppm) at balloon and anthesis results better fruit set as compared to petal fall **(Herrero, 1984)**. With respects to these influential aspects of different growth regulators.

MARTIAL AND METHODS

The current study was carried out during the two successive seasons of 2018 and 2019 on 20 years old of Washington navel orange trees grown in a private orchard located at Sadat district, Minufiya Governorate Egypt. The trees were planted at 4x5 meters a part in sandy soil under 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.

Observations, four branches of approximately same length, diameter and vigor were tagged in each direction before foliar application of GA_3. Number of flowers branch-1were counted 24 hours after foliar application of growth regulator while % fruit set branch^{-1} was determined by using 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 below given 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

After fruit harvest fruit weight and yield per tree was recorded.

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

Fruit Set: Data as shown in Table (1) cleared that GA_3 at 25 ppm sprays significantly increased fruit set in both seasons compared with the control or GA_3 at 5 ppm treatments. Highest fruit set was obtained from the trees received GA_3 sprays, while the lowest fruit set was obtained from the control. The obtained results proved that spraying GA_3 at 25 ppm as well as a positive effect on increasing fruit set. In this respect many investigators noticed that exogenous application of gibberellins was effective in increasing fruit set of Clementine mandarin **(Garcia-Martinez and Garcia-Papi, 1979)**. The obtained results are in harmony with the findings obtained by **(Agusti *et al*., 1982)** who proved that GA_3 sprays at petal fall enhanced fruit set of Washington navel orange tree Fruit set and Percent fruit set per branch. The statistical analysis of data showed significant differences among different GA_3 concentrations, cultivars and their interaction for fruit set and Percent fruit set per branch (Table 1). More number of mean fruits per branch (13.79) were obtained when the plants were treated with the foliar application of 5 ppm GA_3 closely followed by 15 ppm (13.52) which have no significant difference with each other while significantly different from the rest of treatments while less number of fruits (8.81) were observed in control treatment.

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)
				2018			
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
				2019			
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})

The increase in the fruit set and %fruit set might be due to the increased availability of nutrients from leaves by GA_3 while it may also be due to varietal genetic capability to set high or low percentage of fruits. In the findings of present research all treatments showed a significant increase in fruit set of sweet orange cultivars as compared to control treatment. These findings are in line with that of **Garcia-Martinez and Garcia-papi (1979)** who reported that the increase in fruit set after GA_3 application was due to the increased availability of nutrients from leaves. While a single spray of GA_3 at petal fall to the entire tree enhanced initial fruit set **(Agusti *et al.*, 1982)**, similarly a GA_3 spray of (10 ppm) at anthesis resulted in higher set in pear **(Herrero, 1984)**. These findings are also in line with that of **Saleem *et al.* (2008)** who observed the maximum fruit set in 45 mg L-1 treated trees of sweet orange with GA_3 alone or in combination with 2,4-D. The application of GA_3 alone or in combination with benzyl adenine increased the initial fruit set in Pear **(Marcelle, 1984),** similarly the application of GA_3 to the inflorescences 14 days after anthesis significantly increased the fruit set in seedless Clementine Mandarin cultivar 'Fino' **(Garcia-Martinez and Garcia-Papi, 1979)**.

Fruit retention percentage

Fruit drop percentage, June drop percentage and Pre-harvest fruit drop percentage per branch. The analysis of variance showed that foliar application of GA_3, cultivars and their interaction significantly influenced regarding % fruit drop, % June drop and % Pre-harvest fruit drop branch. According to the data given (Table 1) the foliar application of 15 ppm GA_3 gave more mean percent fruit drop (69.07) which was statistically different from the rest of treatments followed by control and 5 ppm treatment (57.49 and 55.23) Respectively, while the minimum percent fruit drop (50.37) was obtained from 25 ppm GA_3. Similarly, mean maximum percentage of June drop (31.35) was noted in control followed by 15 ppm (18.99) while the minimum June drop (9.85) was given by trees treated with 25 ppm GA_3 sprays. Accordingly, more mean % Pre harvest fruit drop (56.24) was observed in trees considered as control followed by 15 ppm (53.91) while less percent pre harvest fruit drop (48.35 and 48.43) was given by trees treated with 5 and 25ppm GA_3 sprays respectively.

The Analysis of Variance showed that GA_3 treatments, cultivars and their interaction were significantly different at ($p<0.05$) level of significance for fruit weight and yield tree-1. However, the application of 25 ppm GA_3 gave maximum mean fruit weight (340.94 g) followed by 15ppm (330.68 g) and (327.89 g) by 5 ppm while minimum fruit mean weight (319.80) was observed in control treatment Similarly the highest value (193.18 Kg) for yield tree-1was obtained by the application of 25 ppm GA_3 followed by 5 ppm (136.83 Kg) while lowest values (134.68 and 135.89 Kg) were noted in 15 ppm and control respectively.

These significant differences among treatments and cultivars towards % fruit drop, %June drop and % preharvest fruit drop might be due to the fruit retentive response of cultivars to these treatments while it might also be due to weather fluctuations apart from genetic differences. The findings of the present research were similar to that of **Yamamura *et al.* (1989)** that the application of GA_3 at the rate of 25, 50 and 100 ppm significantly reduced fruit drop in 'Saijo' and 'Fuyu" cultivars of persimmon. The external application of GA_3 was proved very helpful in preventing fruit drop in mandarins **(Tominaga, 1998)** and sweet orange **(Liao *et al.*, 2006)** these reasons given above can also be supported as high light intensity and dry weather are main factors which accelerate fruit drop. Environmental, nutritional and hormonal factors can cause fruit abscission **(Gillaspy *et al.*, 1993 and Gomez *et al.*, 2000)**. The external application of GA_3 was proved very helpful in preventing fruit drop in mandarins **(Tominaga, 1998)** and sweet orange **(Liao *et al.*, 2006)**. Yield these differences in term of fruit weight and Yield might be due to the application of gibberellic acid besides all other factors like light, temperature, nutrients availability and disease incidence. The present findings of the research study supported the findings of **Ramezani and Shekafandeh (2008)**, who reported that all GA_3 treatments (0, 15, 30 and 45 ppm) significantly increased fruit weight in olive. However, it antagonizes the findings of Garcia-**Martinez and Garcia-papi, (1979)** that (5-200 mg L^{-1}) GA_3 application to Clementine mandarin increased the number of fruits but decrease the average weight $tree^{-1}$**.** Similarly, increase in yield might be due to the application of GA_3 which significantly increased fruit set, decreased fruit drop and also increased the individual fruit weight which in turn increased the final yield tree. The use of plant growth regulators to modify various plant processes is very common in different parts of the world in various crops including citrus. However, the application rate and proper time of application is still a limiting factor in achieving the desired goals. So, it might be concluded from the present research study that 30 ppm GA_3 application at blooming stage increased fruit set and controlled fruit drop at various fruit maturity stages**.**

Leaf Mineral Content

Results in Table (2) showed that GA_3 increased N content in the leaves compared with the control. However, this effect was more pronounced in the second season. Highest leaf N content was obtained from trees sprayed with 25 ppm GA_3. The lowest N content in the leaves in both seasons was obtained from the control. Regarding P content in the leaves, results revealed that GA_3 sprays slightly increased its values than those of the control. However, no significant differences in P leaf content among treatments were developed in both seasons. GA_3 sprays at the high concentration (25 ppm) slightly and insignificantly increased K content in the leaves than the control improved the nutritional status of Washington navel orange trees in term of N, K and Zn contents in the leaves. Such results were supported by **Nijjar (1985)** who mentioned that GA_3 seems to be compatible with micronutrients sprays. The obtained results are in line with the findings of **Samra (1985)** who found that spaying Balady mandarin with zinc increased N content in the leaves. Similarly, the present results are in agreement with those reported by **(Dawood *et al*, 2001)** who found that GA_3 sprays enhanced leaf N content in Balady mandarin. Also, these findings are in accordance with those mentioned by **(Sayed *et al.*, 2004)** who noticed that foliar application of GA_3 having a positive effect on leaf mineral content in orange trees.

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 %**
		2018			**2019**	
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

Effect of foliar spraying with GA_3 on some physical properties average fruit weight and fruit size Data in Table 3 indicated that spraying Washington navel orange with on the physical characteristics of such as fruit weight (g), fruit size (cm^3), specific gravity (g/cm^3) fruit pulp weight (g) and fruit Peel weigh (g) (Table 3). The highest values of fruit weight (g), fruit size (cm^3), fruit peel weight (g) and fruit pulp weight (g) were obtained by using GA_3 at 25 ppm during both 2018 and 2019 seasons, respectively. On the other hand, the highest values of specific gravity (g/cm^3) was obtained from control treatment. This is due to the decrease in fruit weight and fruit size compared with all treatments. The results are in contract by that of **(Abdrabboh, 2013)** who found that spraying Manzanillo olive trees with concentrations fluctuated from 50 to 100 ppm improved the physical fruit properties than untreated plants (control). The present results may be attributed to simulative influence of this bio regulator on cell extension and/or cell division. The increase in fruit size may be attributed to the increase in cell division and cell elongation caused by NAA and GA_3 **(Ranjan *et al.*, 2003)**. **Agrawal and Dikshit (2008)** reported that the application of NAA increased fruit weight and yield by causing cell elongation by enlargement of vacuoles and loosening of cell wall after increasing cell wall plasticity.

Juice volume (cm^3)

Data in Table 3 proved that juice volume was significantly increased by using GA_3 as compared with control in both seasons. The highest juice volume was obtained by using GA_3 at 25 ppm. The obtained finding is in contract with that reported by **Baghdady *et al.* (2014)** who reported that spraying Valencia orange trees with GA_3 at concentrations 15 or 25 ppm at full bloom stage increased fruit juice in comparison to those of control. Also, **Farag and Nagy (2012)** indicated that spraying 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)
				2018			
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
				2019			
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

Concerning the response of polar and equatorial fruit diameters to various GA_3, (Table 3) displayed obviously that different applied treatments of GA_3 significantly increased fruit length (cm) and fruit diameter (cm) in comparison with untreated plants t for the two studied terms. However, GA_3 at 15 ppm at 25 ppm significantly increased the tallest polar and equatorial diameters, followed in descending order by GA_3 at 15 ppm, at 25 ppm in the two studied periods. The present results are in agreement with that reported by **Abd El-Rahman *et al.* (2012)** who reported that foliar application of Washington naval orange with GA_3 at 25 ppm at full bloom stage increased fruit diameter and fruit length. Similarly, **Ghazzawy (2013)** found that foliar (length and diameter) might be due to the GA_3 ability in the division and elongation of the fruit cells. **(Stern *et al.*, 2007)** reported that treatments of cell expansion in the fruit, which in turn, caused an enhancement in fruit volume. We can come to conclusion that foliar application of Washington naval orange with GA_3 at different levels increased fruit weight, fruit size, fruit length, fruit diameter and juice volume (cm^3).

Fruit biochemical characteristics

Effect of foliar spraying with GA_3 on some fruit biochemical characteristics, total soluble solids (TSS) and total acidity percentage Data in Table 4 showed that all GA_3 application significantly improved TSS (%) in comparison to that of the untreated trees (control) in the two studied periods. The highest values of TSS percentage were obtained when trees were treated with GA_3 at 25 ppm followed in descending by GA_3 at 15 in all tested concentrations resulted in a decrease in total acidity% in comparison with control. In this regard, GA_3 at 25 ppm application recorded the least total acidity percentage in Washington navel orange fruits when compared with untreated plants (control) and other application. The results are in agreement with that reported by **Farag and Nagy (2012)** who sprayed Washington naval orange at concentration 25 ppm at full bloom decreased total acidity of as compared with the control.

Also, **Khan *et al.* (2014)** found that application with GA_3 at 20 ppm after fruit set increased TSS 'Blood Red' sweet oranges compared with control. The significant decline in total acidity might be attributed to the incitement happened in orange maturity, whereas the fruit ripened earlier than those of untreated plants (control) **(Hifny *et al.*, 2009)**. Results in (Table 4) showed that TSS/acid ratio significantly improved by increasing GA_3 and NAA rates in the two studied seasons when compared to untreated plants. Maximum values of TSS/Acid ratio were achieved after spraying the Washington navel orange trees with GA_3 at 25 ppm insignificant difference in TSS/Acid ratio was noticed between these treatments and GA_3 treatments. These obtained results are in contract with **Hikal (2013)** on Washington navel orange who found that TSS/acid ratio of fruits was improved while fruit total acidity was reduced by foliar spraying the plants with GA_3 at 20 ppm. Vitamin C (mg/100ml) of fruit juice Data in (Table 4) showed that spraying Washington navel orange trees with GA_3 at different concentrations either individually or in combinations increased

Vitamin C in comparison to that of untreated plants (control) in the two studied seasons. The highest values of Vitamin C were obtained when trees were sprayed with from GA_3 at 25 ppm. The obtained results are in contract with that reported by **Hikal (2013)** who revealed that foliar sprays Washington navel oranges with GA_3 at 20 ppm at pre- harvest increased VC when compared with that of control.

We can come to conclusion that foliar application of Washington navel orange with GA_3 at different concentrations significantly increased TSS (%), Total acidity (%), TSS/ acid ratio and V.C (mg/100 ml) of fruit juice in comparison with that of untreated tree (control). The best foliar application was obtained with GA_3 at 25 ppm in comparison to untreated plants (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
			2018	
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
			2019	
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

REFERENCES

Abd El-Migeed, M.M.M. (2002). Improving productivity and fruit quality of Washington navel orange trees by using some macro-elements and GA_3 sprays. Egypt. J. Appl. Sci., 17(10): 787- 801.

Abd El-Rahman, G.F.; Hoda, M.M. and Ensherah, A.H.T. (2012). Effect of GA_3 and potassium nitrate in different dates on fruit set, yield and splitting of Washington navel orange. Nature and Science, 10 (1): 148-157.

Abdrabboh, G.A. (2013). Effect of some growth regulators on yield and fruit quality of manzanillo olive trees. Nature and Science, 11 (10): 143-151.

Agrawal, S. and Dikshit, S.N. (2008). Studies on the effect of plant growth regulators on growth and yield of sapota (*Achras sapota* L.) cv. Cricket Ball. Indian J. Agric. Res., 42: 207-211.

Agusti, M. (2000). Regulation of citrus cropping and improvement of fruit quality using exogenous plant growth regulators. Proc. Int. Soc. Citricult.IX Congr, 351-356.

Agusti, M.; Garcia-Mari, F. and Guardiola, J.L. (1982).” Gibberellic acid and fruit set in sweet orange”, Scientia Hort., 17(3): 257-264.

Agustí, M.F. and Almela, V.O. (1991). Aplicación de fitorreguladores em citricultura. Barcelona, Aedos., 261 p.

Baghdady, G.A.; Abdelrazik, A.M.; Abdrabboh, G.A. and Abo-Elghit, A.A. (2014). Effect of foliar application of GA_3 and some nutrients on yield and fruit quality of Valencia orange trees. Nature and Science, 12 (4): 93-100.

Dawood, S.A.; Meligy, M.S. and El-Hamady, M.M. (2001). How to regulate cropping in Balady mandarin trees (A) using gibberellins. Minufiya J Agric. Res., 26(3): 869-882.

El-Otmani, M. (1992). Principal growth regulator uses in citrus production. Proc. 2nd Seminar on Citrus Physiology. Bebedouro. Ed. Cargill. pp. 55-69.

El-Sese, A.M.A. (2005). Effect of gibberellic acid (GA_3) on yield and fruit characteristics of Balady mandarin. Assiut. J. Agri. Sci., 36(1): 23-35

Farag, K.M. and Nagy, N.M. (2012). Effect of pre and post-harvest calcium and magnesium compounds and their combination treatments on" Anna" apple fruit quality and shelf life. Journal of Horticultural Science & Ornamental Plants, 4(2): 155- 168.

Garcia-Martinez, J.L. and Garcia-Papi, M.A. (1979).” The influence of Gibberellic acid, 2, 4-dichlorophenoxyacetic acid and 6-benzylaminopurine on fruit-set of Clementine mandarin”, Scientia Hort., 10(3): 285-293.

Ghazzawy, H.S. (2013). Effect of some applications with growth regulators to improve fruit physical, chemical characteristics and storage ability of

Barheedate palm cultivar. Int. Res. J. Plant Sci., 4(7): 208-213.

Gillaspy, G.; David, H.B. and Gruissem, W. (1993). "Fruits: a developmental perspective", J. Plant Cell, 5: 1439-1451.

Gomez, C.A.; Mehouachi, J.; Tadeo, F.R.; Primo, M.E. and Talon, M. (2000)." Hormonal regulation of fruit let abscission induced by carbohydrate shortage in citrus", Plant., 210: 636-643.

Guardiola, J.L.; Barries, M.T.; Albert, C. and Garcia-Louis, A. (1993)." Effect of exogenous growth regulators on fruit development in Citrus unshiu", Ann. of Bot. 71(2): 169-176.

Herrero, H. (1984)." Effect of timing of GA_3 treatment on 'Agua de Aranjuez' pear fruit set", ISHS Acta Hort., 149,1 (27).

Hifny, H.A.; Fahmy, M.A.; Edriss, M.H. and Hamdy, A.E. (2009). Effect of CCC foliar spray on improvement of flowering and yield production of some olive cultivars. Al-Azhar J. Agric. Sci. Sector Res., 6: 195-217.

Hikal, A.R. (2013). Effect of Foliar Spray with Gibberellic Acid and Amcotone on Fruit Set, Dropping, Component Yield and Fruit Quality of Washington Navel Orange Trees. J. Plant Production, Mansoura Univ., 4 (6): 1015 - 1034.

Khan, A.S.; Shaheen, T.; Malik, A.U.; Rajwana, I.A.; Ahmad, S. and Ahmad, I. (2014). Exogenous applications of plant growth regulators influence the reproductive growth of *Citrus sinensis* osbeck CV. Blood red. Pak. J. Bot, 46 (1): 233-238.

Krezdorn, A.H. (1965). Fruit setting problems in citrus Proc. Carib. Reg. Amer. Soc. Hort. Sci., 9: 85-92.

Liao, H.L.; Chen, H. and Chung, K.R. (2006). Plant hormone inhibitors for reducing post bloom fruit drop of citrus, Proc. Fla. State Hort. Soc., 119: 78-81.

Marcelle, R.D. (1984). Effect of GA_3, BA and growth retardants on fruit set in the pear cultivar Doyenné du Comice, ISHS Acta Hort., 149: 1 (27).

Ministry of Agric., A.R.E., (2015). Agric. Econ-Bull. Ministry of Agric. Egypt, 2015.

Morton, J.F., (1987). Orange. P. 134-142. in: Fruits of warm climates. Miami, FL. 1987.

MSTAT-C (1990). A microcomputer program for the design, management and analysis of agronomic research experiments, Michigan State University.

Nijjar, G.S. (1985). Nutrition of fruit trees. Mrs Usha Raj Kumar. Kalyani, New Delhi, India, pp: 1-89.

Rabe, E. (2000). Fruit thinning for enhanced fruit size: an overview of strategies. p.595- 601. In: Proc. Int. Soc. Citricult. IX Congress.

Ramezani, S. and Shekafandeh, A. (2008). "Roles of Gibberellic acid and zinc sulphate in increasing size and weight of olive fruit", African J. of Biotech. 8 (24).

Ranjan, R.; Purohit, S.S. and Prasad, V. (2003). Plant Hormones: Action and Application. Agrobios, India, pp. 183–189.

Reig, C.; Farina, V.; Volpe, G.; Mesejo, C.; Martínez-Fuentes, A.; Barone, F.; Calabrese, F. and Agusti, M. (2011). "Gibberellic acid and flower bud development in loquat (*Eriobotrya japonica* Lindl.)", Scientia Hort., 129 (1): 27-3.

Saleem, B.A.; Malik, A.U.; Pervez, M.A. and Khan, A.S. (2008). "Growth regulators application affects vegetative and reproductive behavior of 'Blood Red' Sweet orange", Pak. J. Bot., 40 (5): 2115-2125.

Samra, N.R. (1985). Yield and fruit quality of Balady mandarin as affected by zinc and GA_3 application. J. Agric. Sci. Mansoura University, 10(4): 1427-1432.

Sayed, R.A; Solaiman, B.M. and Abo-El Komsan, E.O. (2004). Effect of foliar sprays of some mineral nutrients, GA_3 and \ or biostimulant on Yield and fruit quality of Valencia orange trees grown in sandy soil. Egypt. J. Appl. Sci., 19(5): 222-238.

Snedecor, G.W. and W.G. Cochran (1990). Statistical methods (6th ed). The Iowa State. Univ.

Stern, R.A.; Flaishman, M. and Ben-Arie, R. (2007). Effect of synthetic auxins on fruit size of five cultivars of Japanese plum (*Prunus saliciana* Lindl.). Scientia Horticulturae, 112: 304-309.

Tominaga, S. (1998). "GA sprays delay and reduce physiological fruit drop in Ponkan mandarin (*Citrus reticulata* Blanco)", ISHS Acta Hort. 463: 301-305.

Villafane, V.E.; Munoze, F.J.E. and Torres, H.R. (1989). Flowering growth and ripening of the orange Washington Valley Citrus, Acts. Agronomica, Universidad-Nacional de Colombia, 39(3-4): 142-149.

Yamamura, H.; Matsui, K. and Matsumoto, T. (1989). "Effects of gibberellins on fruit set and flower-bud formation in unpollinated persimmons (*Diospyros kaki*)", Scientia Hort., 38(1-2): 77-86.