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Ga3 and Zinc Sprays for Improving Yield and Fruit Quality of Washington Navel Orange Trees Grown under Sandy Soil Conditions

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Abstract: This study was carried out during two successive seasons (2005 and 2006) on ten years old Washington navel orange trees (*Citrus sinensis L. Osbeck*) budded on Volkamer lemon (*C. volkamerina L.*) rootstock, grown in sandy soil in a private orchard at Sadat district, Minufiya Governorate, Egypt. GA_3 at 10 or 20 ppm was sprayed twice (beginning of April and beginning of June) also,chelated zinc at 0.4% was sprayed three times (mid February, beginning of April and beginning of June). The obtained results revealed that most treatments especially those included zinc sprays improved leaf N, K and Zn contents. However data proved that GA_3 sprays at 20 ppm were more effective than that at 10 ppm in term of fruit set, fruit retention and yield as fruit number or weight (Kg) per tree. Spraying 0.4% chelated zinc alone or with GA_3 especially at 20 ppm significantly increased fruit set, fruit retention, decreased fruit drop and subsequently improved the yield as well as the physical and chemical fruit characteristics. So, spraying 0.4% chelated zinc at mid February followed by spraying 0.4% chelated zinc + 2o ppm GA_3 twice at (beginning of April and beginning of June) seems to be the promising treatment for increasing productivity of low yield Washington navel orange trees grown under sandy soil condition.

Keywords: GA3, Zinc spray, navel orange, leaf mineral content , yield and fruit quality and sandy soil.

INTRODUCTION

In Egypt, citrus is considered the first fruit crop either for local consumption or export demands. Citrus acreage reached 359703 feddans. Oranges represent more than sixty percent of this acreage. Washington navel, the main orange c.v. occupies about 56% of the total oranges area, most Washington navel cv. is planted in the old valley while the rest (12%) is found in the newly reclaimed lands[19] this may be due to inadequate fruit set and sever fruit drop which represent the major causes of navel orange low yield under sandy soil conditions[23,20]. The beneficial effects of GA_3 and nutrient elements sprays specially zinc on yield and fruit quality of fruit crops were mentioned by many investigators as Morton,[21] 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 and zinc were suppoted by Agusti *et al*.,[4], Abd El-Migeed,[1] and Sayed *et al*.,[30] on oranges, El-Sese *et al*.,[11] on mandarin, Mostafa *et al*.,[22] on pear and El-Sharkawy and Mehiesen[12] on guava. In addition, zinc deficiency is the most common in areas with alkaline soils However, Zn deficiency is corrected by foliar sprays. In this respect, zinc chelate can be applied safely at any time of the growth season at proper rates[27]. Moreover, zinc foliar sprays before anthesis may be beneficial in terms of fruit yield in citrus and grapes Swietlik,[33]. The positive effects of zinc sprays on nutritional status, fruit set,fruit retention, reducing fruit drop, yield and fruit quality were supported by many investigators, Anora *et al*.,[5] on Sweet lime, Shawky *et al*.,[31] Ismail,[14], Nahklla,[23] and Sayed *et al*.,[30] on oranges. Accordingly, this work was planned as a try to overcome the problem of low yield of Washington navel orange trees grown under sandy soil conditions through studing the influence of GA_3 and zinc sprays on tree nutritional status, fruit set, fruit drop, fruit retention, yield and fruit quality.

MATERIALS AND METHODS

This trial was carried out during two successive seasons (2005 and 2006) on ten years old Washington navel orange trees (Citrus sinensis L. Osbeck) budded on Volkamer lemon (C. volkamerina L.) rootstock. Trees were planted at 5×5 meters apart on sandy soil under drip irrigation system in a private orchard at Sadat district, Meunofiya Governorate, Egypt. Soil was analyzed by using the methods described by Cottenie *et al*.[7], Table (1).

All trees were subjected to the same cultural practices in both studied seasons. Eighteen trees were

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selected as uniformed in vigor as possible. The experiment involved six foliage spraying treatments as follows:

- Control (sprayed with water).
- 10 ppm GA_3
- 20 ppm GA_3
- Zn
- Zn + 10 ppm GA_3
- Zn + 20 ppm GA_3

Where GA_3 = gibberellic acid (berelex), Zn = 0.4 % chelated zinc (12 % Zn).

A complete randomized block design was arranged where each treatment was replicated three times on one – tree / plots. GA_3 at 10 or 20 ppm was sprayed twice (at beginning of April and beginning of June). Zinc was sprayed three times (on mid February, beginning of April and beginning of June) in 2005 and 2006 seasons. All trees received the spraying solution (about ten liters/ tree) till run off. Misrol liquid soap (1ml/l) was used as a wetting agent. Eight shoots of about 2.5 cm diameter at the same height around each tree were chosen, two of them toward each direction were labeled during the current spring growth cycle to carry out the following measurements:

Leaf Mineral Contents: In late August of each season, forty leaves of 5-7 months old from tagged non-fruiting and non-flushing terminals of spring growth cycle were collected[16].Leaf samples were washed with tap water, then with distilled water and dried at 70 ºC until constant weight, finally, ground and digested using the method of Piper[26]. The digested solution was used for the determination of each of N using micro kjeldahel menthod outlined by Jackson[15].

Phosphorus by using the method of Walanabe and Olsen[35].

K and Zn, by using Atomic Absorption Spectrophotometer "Perkin Elmer 1100 B" after[6].

The above mentioned nutrients were calculated as percentage on dry weight basis except Zn was calculated as ppm on dry weight basis

Number of Flowers: The number of flowers at full bloom was counted for each labeled branch.

Fruit Set: The numbers of fruit set two weeks after full bloom were counted and fruit set % was estimated according to the following equation

$$\textit{fruit set} = \frac{\textit{Total No. of fruitlets}}{\textit{Total No. Of flowers}} \times 100$$

Fruit Drop (June Drop): Fruits were counted again on each branch at the end of June and June drop % was determined as follows:

$$\textit{June drop} = \frac{\textit{Total No. Of fruitlets - No. of fruits in late June}}{\textit{Total No. Of fruitlets}} \times 100$$

Fruit Retention: The number of fruits retained till harvest time on the same branch was counted and fruit retention estimated.

$$\textit{Fruit retention} = \frac{\textit{No. of retained fruits}}{\textit{Total No. Of fruielets}} \times 100$$

In late December, yield per tree was determined as number and weight of fruits (kg)/tree in 2005 and 2006 seasons.

For fruit quality a sample of five fruits/tree was randomly taken at harvest to determine fruit weight, fruit diameter, peel thickness, total soluble solids, titratable acidity and ascorbic acid contents using the methods described in[2]. The data were subjected to analysis of variance and Duncan's multiple test to differentiate means[9].

RESULTS AND DISCUSSIONS

Leaf Mineral Content: Results in Table (2) showed that GA_3 and zinc sprays alone or in combinations 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 20 ppm GA_3 + 0.4 % chelated zinc (T_6). 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 and/or zinc 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.

Potassium content in the leaves was increased by treatments included zinc sprays compared with the control. However GA_3 sprays only at the high concentration (20 ppm) slightly and insignificantly increased K content in the leaves than the control. Results in Table (2) indicated that spraying zinc alone or with GA_3 significantly increased Zn content in the leaves compared with the control or GA_3 sprays alone. However, GA_3 and/or zinc raised Zn content in the leaves from the low to the optimum range (25-100 ppm) Jones and Embleton[17]. From the above results, it obvious that spraying GA_3 specially at

Table 1: Physical and chemical soil analysis

a- Mechanical analysis:											
Sand,%			Silt,%				Clay,%				Texture
90			5				5				Sandy
b- Chemical analysis:											
			Soluble cations,meq/l					Soluble anions, meq/l			
pH(1:2.5)	EC{1:1}dsm^{-1}	$CaCo_{3\%}$	N ppm	K	Na	Ca	Mg	Cl	So_4	HCO_3 mg/l	CO_3
8.2	1.5	5.5	trace	0.57	9.18	2.65	2.4	5.3	5.65	3.85	----

Table 2: Effect of GA_3 and/or zinc sprays on N, P, K and Zn contents of Washington navel orange leaves in 2005 and 2006 seasons.

No.	N %		P %		K %		Zn ppm	
Treatments	2005	2006	2005	2006	2005	2006	2005	2006
1- Control	2.15	2.10 b	0.12	0.14	1.2	1.17 b	19 b	23 c
2- 10 ppm GA3	2.19	2.27 a	0.16	0.15	1.19	1.09 b	18 b	25 c
3- 20 ppm GA3	2.25	2.32 a	0.16	0.16	1.26	1.20 b	19 b	25 c
4- Zn	2.23	2.30 a	0.14	0.15	1.2	1.35 a	37 a	46 b
5- Zn + 10 ppm GA3	2.3	2.31 a	0.15	0.16	1.33	1.42 a	48 a	57 a
6- Zn + 20 ppm GA3	2.32	2.39 a	0.14	0.16	1.2	1.35 a	37 a	41 b
Significance at 5% level	NS	S	NS	NS	NS	S	S	S

Means having the same letters within a column are not significantly different at 5% level.S: significantNS: not significant

the high concentration in combination with zinc had 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[24] who mentioned that GA_3 seems to be compatible with micronutrients sprays. The obtained results are in line with the findings of Samra[29] 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*,[8] 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*,[30] who noticed that foliar application of GA_3 and zinc having a positive effect on leaf mineral content in Valencia orange trees.

Fruit Set: Data as shown in Table (3) cleared that GA_3 at 20 ppm and/or zinc sprays significantly increased fruit set in both seasons compared with the control or GA_3 at 10 ppm treatments. Highest fruit set was obtained from the trees received GA_3 with zinc sprays, while the lowest fruit set was obtained from the control.The obtained results proved that spraying GA_3 at 20ppm as well as chelated Zn at 0.4 % has 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[32]. The obtained results are in harmony with the findings obtained by Agusti *et al*.,[4] who proved that GA_3 sprays at petal fall enhanced fruit set of Sweet orange tree. Also, the present results were supported by El Sese[11], on Balady mandarin and El–Sharkawy and Mehaisen[12], on guava trees. Similarly, the obtained results are in agreement with Nakhlla[23] on Navel orange, who found that chelated Zn sprays at 0.4% significantly increased fruit set percentage.

Fruit Drop: Results in Table (3) indicated that GA_3 and or zinc sprays markedly decreased fruit drop. Generally, fruit drop was higher in the first season than in the second one. However, a particular trend noticed in this concern, that GA_3 sprays decreased fruit drop compared to the control, this effect was more cleared in the 2005 season. Similarly, zinc sprays decreased fruit drop than that of the control or those sprayed with GA_3 alone. The lowest fruit drop obtained from trees sprayed with zinc + GA_3 at 10 ppm. The present results are in agreement with the findings obtained by Agusti[3] who concluded that the reduction in fruit drop as a response of GA_3 treatments might be due to an increase in initial growth of ovaries and reduce magnitude the peak of abscission. Moreover, the reduction in fruit drop obtained due to zinc sprays could be attributed to its effect on enhancing formation and translocation of carbohydrates and carbohydrate enzymes[36].

Fruit Retention: As shown in Table (3) results indicate that GA_3 and/or zinc sprays significantly increased fruit retention over the control. Spraying 0.4% chelated zinc+20 ppm GA_3 recorded high

Table 3: Effect of GA_3 and/or zinc sprays on fruit set, fruit drop, fruit retention and yield of Washington navel orange trees in 2005 and 2006 seasons.

No.	No. of fruit/ tree		Fruit set %		Fruit drop %		Fruit retention %		Yield (kg) / tree	
Treatments	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
1- Control	125b	127c	20.4c	27.9b	80.7a	73.9a	34.7c	36.2c	34.7c	36.2c
2- 10 ppm GA3	151b	169b	22.7c	28.5b	77.2a	69.8b	42.9bc	50.5ab	42.9bc	50.5ab
3- 20 ppm GA3	179a	185b	28.0b	34.5a	77.5a	69.6b	53.1ab	52.9ab	53.1ab	52.9ab
4- Zn	190a	202ab	33.7a	35.6a	66.3b	54.7c	52.3ab	60.7ab	52.3ab	60.7ab
5- Zn+ 10 ppm GA3	198a	228a	35.4a	38.3a	52.8c	51.7c	57.2a	61.9ab	57.2a	61.9ab
6- Zn+ 20 ppm GA3	206a	228a	36.1a	37.5a	53.1c	53.0c	62.1a	68.3a	62.1a	68.3a
Significance at 5 % level	S	S	S	S	S	S	S	S	S	S

Means having the same letters within a column are not significantly different at 5% level.S: significant

Table 4: Effect of GA_3 and/or zinc sprays on some physical and chemical fruit characteristics of Washington navel orange trees in 2005 and 2006 seasons

No.	Fruit weight (gm)		Fruit diameter (cm)		Peel thickness (cm)		Acidity (%)		T.S.S %		Ascorbic acid (mg/100 ml juice)	
Treatments	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
1- Control	273c	277	6.43b	6.90c	0.42b	0.40b	0.81	0.80b	9.8c	10.0b	42	41d
2- 10 ppm GA3	298ab	285	7.13ab	7.33b	0.45b	0.48ab	0.85	0.82ab	10.2bc	10.4b	43	42cd
3- 20 ppm GA3	285bc	296	7.00ab	7.50ab	0.48b	0.55ab	0.84	0.83ab	10.5abc	10.6b	43	43cd
4- Zn	304ab	286	7.53a	7.63ab	0.57a	0.59ab	0.84	0.79b	11.5a	11.6a	49	47bc
5- Zn+ 10 ppm GA3	311a	284	7.73a	7.75a	0.60a	0.58ab	0.85	0.83ab	11.3a	12.0a	50	50a
6- Zn+ 20 ppm GA3	314a	302	8.0a	7.80a	0.61a	0.60a	0.86	0.87a	11.5a	11.6a	50	53a
Significance at 5 % level	S	NS	S	S	S	S	NS	S	S	S	NS	S

Means having the same letters within a column are not significantly different at 5% level.S: significantNS: not significant

fruit retention values in both seasons. In this respect, Nijjar[24], mentioned that zinc is required for preventing the abscission layer formation and consequently, the reduction in pre-harvest dropping. The obtained results are in line with those found by Anora *et al*.,[5] who mentioned that double zinc sprays at 0.5 % increased final fruit retention of Sweet lime. Similar results were obtained by Gregoriu *et al*.,[13] who found that GA_3 has a preventive effect on June and pre-harvest drop in oranges.

Yield: Yield as number or weight (Kg) of fruits per tree as shown in Table (3) increased by most tested treatments in 2005 and 2006 seasons than the control. In this respect, a particular trend was noticed that GA_3 sprays at the high concentration (20 ppm) was more effective in improving yield than spraying GA_3 at 10 ppm. Moreover, spraying zinc alone or in combination with GA_3 at any concentration significantly increased yield in the two seasons comparing with the control. Highest yield obtained from trees sprayed with 20 ppm GA_3+ 0.4 % chelated zinc.

The obtained results of GA_3 sprays are in line with those reported by El-Sese[11] who found that Balady mandarin trees sprayed at full bloom with GA_3 resulted in increased yield as number or weight (Kg) of fruits/ tree. The obtained results also supported by Agusti *et al*.,[4]) on Sweet orange, Mostafa *et al*.,[22] on pear, Abd El-Migeed[1] on Washington navel and El-Sharkawy and Mehaisen[12] on guava.

Increasing yield due to GA_3 or zinc sprays may be attributed to their effects on increasing levels of IAA more than increasing fruit set[34], Nakhlla[23] and Raphael *et al*.,[28]. Simillarly the present results were supported by the findings obtained by Shawky *et al*.,[31] Ismail[14] who found that foliar application of zinc increased yield of Navel and Valencia oranges. Also, Swietlik[33] concluded that zinc foliar sprays applied before anthesis may be most beneficial in terms of fruit yield in citrus and grapes. It could be concluded that the enhancement previously mentioned in yield may be attributed to the improvement in the nutritional status specially zinc.

Fruit Quality: Data in Table (4) show the effect of GA_3 and/or zinc sprays on some physical and chemical fruit properties of Washington navel orange trees in 2005 and 2006 seasons.

Physical Properties: Fruit weight (gm). As shown in Table (4),fruit weight improved by all treatments comparing with the control. However, this effect was more noticed in the first season. Highest fruit weight was obtained from trees sprayed with0.4% chelated Zn + 20 ppm GA_3 while, fruits taken from the control trees recorded the lowest fruit weight values in both seasons.

Peel thickness (cm) slightly and insignificantly increased by GA_3 sprays. However, spraying zinc alone or with GA_3 at 20 ppm significantly increased peel thickness compared with the control that gave the lowest peel thickness values in the two seasons.

Fruit diameter (cm).Table (4) showed that fruit diameter improved by most tested treatments. Spraying zinc alone or with GA_3 at any concentration markedly increased fruit diameter comparing with the control.

From the above results it seems that physical fruit properties in terms of fruit weight, peel thickness and fruit diameter was improved by most treatments specially those included zinc sprays. The role of GA_3 in improving fruit quality namely, fruit weight, peel thickness and fruit diameter may explained due to its role in increasing cell elongation, Pharis and King[25].

However, the present results supported by the findings obtained by Sayed *et al*.,[30] who found that fruit weight, peel thickness and fruit diameter of Valencia orange were increased due to GA_3 sprays.

The improvement occurred in fruit quality due to supplying trees with zinc could be attributed to its effects on enhancing formation and translocation of carbohydrates and carbohydrate enzymes[36].

Chemical Properties: Total soluble solids (TSS). Results in Table (4) showed that GA_3 sprays slightly increased TSS compared to the control in both seasons. However, spraying zinc alone or with GA_3 significantly increased TSS than the control. This means that the significant increase in TSS was mainly due zinc not to GA_3.

Acidity. Data in Table (4) cleared that juice acidity was significantly affected in the second season. Spraying zinc +20 ppm GA_3 significantly increased juice acidity compared with the control or with those sprayed with zinc alone. This means that the presence of GA_3 at the high concentration (20 ppm) with zinc sprays tended to increase juice acidity. This may be due to the effect of GA_3 on delaying maturity. Ju *et al*.,[18].

Ascorbic acid (V.C). Data in Table (4) indicated that (V.C) content in fruit juice, followed in general, the same trend obtained by different treatments on juice acidity. However, treatments included zinc significantly increased V.C in fruit juice than the control. High V.C obtained by spraying zinc and GA_3 sprays. This means that the presence of GA_3 irrespective to its concentration with zinc sprays has a positive effect on vitamin C in fruit juice. This effect obviously noticed in 2006 season. The present results are in line with the findings obtained by El-Menshawi *et al*.,[10] who concluded that zinc sprays increased fruit weight, peel thickness, TSS and V.C in Balady mandarin trees. Similarly, Nakhlla[23] on Navel orange reported that Zn sprays increased TSS and V.C contents of the fruits.

It could be noticed from the present study that GA_3 is not only compatible with nutrient elements i.e. zinc on nutritional status, Najjar[24], but proved that GA_3 is also compatible with zinc in terms of yield as well as fruit quality.

From the above mentioned results, it could be concluded that spraying 0.4% chelated zinc at mid February followed by spraying 0.4% chelated zinc + 2o ppm GA_3 twice at (beginning of April and beginning of June) seems to be the promising treatment not only to overcome the low yield problem of Washington navel orange trees grown under sandy soil condition but also for improving fruit quality.

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