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Effect of Application of Some Growth Regulators and $CaCl_2$ on Fruit Drop, Yield and Fruit Quality of Keitt Mango Trees

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Abstract

The present study was carried out during the two successive seasons of 2014 and 2015 on eight years old Keitt mango trees, in order to investigate the effect of spraying each of NAA(40ppm), GA_3(40ppm), CPPU(10 ppm), BA (40ppm), SA (250 ppm) and $CaCl_2$ (0.75%) after fruit set on fruit drop, yield and fruit quality of Keitt mangoes trees. Trees were spaced at 2 X 3 meters apart and grown in a sandy soil at a private orchard in Edko region, El-Behera governorate, Egypt. Trees were sprayed twice; after fruit set and 30 days later in a randomized complete block design (RCBD). The results showed that the fruit drop percentage after one, two and three months from the application date was significantly decreased and the fruit retention percent and yield per tree were increased by all sprayed substances in comparison with the control in both seasons. Generally, trees spraying with NAA, GA_3, CPPU or BA was considered the best and effective in decreasing fruit drop and increasing fruit retention and tree yield. Spraying GA_3, SA and CPPU improved some fruit physical characteristics in comparison with the control. In the meantime, spraying SA, NAA and $CaCl_2$ had positive influence on fruit chemical characters in comparison with the control.

***Keyword**: Mango trees, Growth regulators, Fruit quality.*

1. Introduction

Mango is one of the most important tropical fruits worldwide in terms of production and consumer acceptance. (Kostermans and Bompard, 1993). Fruit drop is one of the major problems contributing to yield decline of the Keitt cultivar grown at the Edko region, El-Behera governorate. It is well known in many tree fruits, including mango, that retention of a fruit, i.e., the capacity of a fruit to prevent itself from being shed, relates positively to the ability of the fruit to attract nutrients, which in turn is dependent on the fruit's ability to produce growth promoting hormones (Wolstenholme and Robert, 1991).

In spite of adequate flowering, low fruit yields in mango orchards have been experienced because of low initial fruit set and subsequently higher fruit abscission (Singh and Singh, 1995). Fruit abscission is a very complex physiological process, occurs in many cultivars and at all stages of development, but it is particularly high during the first 3-4 weeks after pollination and accounts for over 90% loss of set fruitlets (Bains *et al*., 1997 and Wahdan and Melouk, 2004). Several factors affect fruit abscission and some of the suggested reasons were the lack of pollination and failure of fertilization, disturbances in embryogensis and/or embryo abortion, sink competition between fruits, hormone content, nutrient deficiency, climatic factors, inadequate soil moisture and low pho-

tosynthetic level (Whiley, 1986; Chadha, 1993; Bains *et al*., 1997 and Marcelis *et al.,* 2004).

Plant growth regulators have been reported to play a major role in fruit growth and fruit drop of mango (Ram, 1992), which counteract the enzymes responsible for creating the abscission zone and result in fruit drop reduction. Deficiency of auxins, gibberellins and cytokinins, as well as high level of inhibitors appear to be the cause of fruit drop in mango trees (Krisanapook *et al*., 2000 and Ram, 2000). Auxins, gibberellins, cytokinins as well as salicylic acid are of the several growth regulators exogenously applied to horticultural crops.

Many researches had reviewed the role of such growth regulators in increasing the yield and quality of mango trees. Oosthuyse (1993) found that spraying Tommy Atkins and Heidi cvs. with 40 ppm GA_3 plus 10 ppm CPPU enhanced fruit retention.

Also, Notodimedjo (2000) stated that "spraying Arumanis cv. with CPPU at 10 ppm increased fruit retention, number of fruits per cluster and per tree and fruit weight and volume". In addition, Sasaki and Utsunomiya (2002) reported that spraying Irwin cv. with double combination of (10 ppm CPPU plus 100 ppm GA_3) increased the commercial value of Irwin mango fruits. Kassem and Marzouk (2004) reported a significant increase in fruit retention and decrease in fruit drop by applying 30 ppm NAA and 50 ppm GA_3 at the pea stage to Zebda mango trees. Spraying calcium was found to increase mango tree productivity due to the reduction of abscission (Kumar *et al*., 2006).

Boshra (2007) sprayed Hindi Be Sinnara mango trees with CPPU, GA_3 and NAA alone or in double combinations of CPPU plus GA_3 14 days after blooming and indicated that the highest fruit set and yield were obtained with spraying combination of 10 ppm CPPU plus 40 ppm GA_3.

Vejendla *et al.*(2008) found that sprayed Amrapali mango trees with NAA at 50 ppm twice, one at pea stage and other at marble stage recorded maximum fruit retention per panicle, highest number of fruits per plant and yield.

Al-Qurashi and Awad (2011b) found that spraying date palms with NAA, GA_3 and BA 40 and 70 days after pollination significantly decreased fruit drop.

Moreover, Wahdan *et al*. (2011) reported that spraying mango cv. "Succary Abiad" with 40 and 60 ppm NAA, 2% $CaCl_2$ and 20 and 40 ppm GA_3 twice after full bloom led to increasing fruit retention percentage and yield. Moreover, Nkansah *et al*. (2012) revealed that spraying Keitt mango trees with GA_3 and NAA each at 25 and 50 ppm at full bloom stage significantly increased fruit retention and tree yield with best results of fruit retention, number of fruits per cluster and per tree.

Ahmed *et al*. (2014) mentioned that spraying Keitt mango trees three times with SA at 100 ppm was responsible for improving the percentage of fruit retention, as well as, yield and number of fruits per tree over the check treatment. Mean while, El Gammal *et al.* (2015) reported a significant enhancement in Keitt mango fruit retention and yield as a result at foliar application of GA_3 at 20 and 40

ppm and NAA at 25 and 50 ppm twice at full bloom.

Therefore, the objective of the present study was to investigate the effect of spraying NAA, GA_3, CPPU, BA, SA and CaCl2 after fruit set on fruit drop, yield and fruit quality of Keitt mango trees grown in Edko region, El-Beheera governorate, Egypt.

III. Materials and Methods

Experimental sites, growing conditions and plant material

The present study was carried out during the two successive seasons of 2014 and 2015 on eight years old Keitt mango trees [*Mangifera indica*.L] budded on Sukkary seedling rootstocks. Trees were spaced at 2 X 3 meters apart and grown under fertigation system in a sandy soil at a private orchard in Edko region, El-Behera governorate.

Applied treatments and statistical design

Twenty one healthy and uniform trees were selected and were subjected to seven foliar application treatments with three replicates /treatment (each replicate represents one tree) in a randomized complete block design (RCBD). Trees were sprayed twice; after fruit set and 30 days later with the following foliar spray treatments and their effect on fruit retention, drop, tree yield and fruit growth and quality was assessed:

1- Water only (control).

2- Naphthalene acetic acid, NAA (40 ppm).

3- Gibberellic acid, GA_3 (40 ppm).

4- Cytofex; N-(2-chloro-4-pyridyl)-N-phenylurea, CPPU (10 ppm).

5- Calcium chloride, $CaCl_2$ (0.75%).

6- Benzyl adenine, BA(40 ppm).

7- Salicylic acid, SA (250 ppm).

The selected trees were sprayed until run-off, and Bio New film (produced by Misr El-Dawliya) was added as a surfactant agent at 60 ml / 100 L water to all sprayed treatments including the control to reduce the surface tention. Fruit drop, retention, tree yield as well as fruit quality characteristics at harvest date were measured.

Measured parameters

Fruit drop and fruit retention:

The number of fruits per tree was counted after fruit set to determine the initial number of fruits per tree. The fruit drop was calculated as a percentage of the initial fruit set, the number of fruits per tree after one, two and three months in relation to the initial number of fruits per tree and fruit retention were calculated as follows:

$$\text{A - Initial fruit retention (\%)} = \frac{\text{Fruits number after June drop}}{\text{Initial fruits number}} \text{ x } 100.$$

$$\text{B - Final fruit retention (\%)} = \frac{\text{Final fruits number}}{\text{Initial fruits number}} \text{ x } 100.$$

Tree yield:

At harvest date, mid-October of each season, number of full, matured fruits per tree was counted and tree yield was recorded as number and weight (Kg) of fruits / tree. A sample of three fruits from each replicate was taken for measuring the following fruit quality parameters.

Fruit quality:

Average fruit weight, peelplus pulp and seed weight (g) were measured and peel plus pulp/fruit ratio was

calculated. Also fruit length and fruit width (cm) were measured with a caliper and fruit shape index (length/width) was estimated. In addition, fruit firmness (Newton) was measured according to Magness and Taylor (1925) by pressure tester using a (8mm) "plunger". Two readings were taken in two opposite sides on the flesh of each fruit after peeling. Newton (N) = kilogram-force (kgf) x 9.807

In addition, for determining fruit chemical characteristics, the fruit pulp was squeezed and in the fruit juice; the percentage of total soluble solids (TSS) was determined using hand refractmeter. Fruit acidity (%) expressed as citric acid was determined by titrating with 0.1 N sodium hydroxide in the presence of phenolphthalein as an indicator according to AOAC (2000) and the TSS /acidity ratio was calculated. Moreover, fruit total sugars percent were determined by using the phenol sulfuric acid method outlined by Malik and Singh (1980). Fruit reducing sugars content was determined colorimetrically according to Nelson (1944). Non-reducing sugars were calculated by the difference between total sugars and reducing sugars. In addition, ascorbic acid (Vitamin C) was measured by the oxidation of ascorbic acid with 2,6-dichlorophenol endophenol dye, and the results were expressed as mg/100 ml juice (Ranganna, 1986). Soluble phenols content was determined as a percentage of the fresh weight of mango pulp (5g) according to the method described by Swain and Hillis (1959). One gram was taken from the whole fruit pulp and was extracted in 10 ml acetone (85%) and carotenoids contents was determined colorimetrically at a wave length 440 nm using spectrophotometer as described by Wintermans and Mats (1965).

Statistical analysis:

All data were tested for treatments effects on analyzed parameters by one-way analysis of variance (ANOVA) technique. Treatment means were separated and compared using least significant difference (L.S.D) at 0.05 level of propability according to Steel and Torrie (1980). The statistical analysis was performed using SAS (Statistical Analysis System) version 9.13, (2008).

IV. Results and Discussion

Fruit drop and fruit retention:

The effect of the different treatments on fruit drop percentage is presented in Table (1). Results of both seasons showed that all treatments significantly decreased the fruit drop percentage after one month from the application date in comparison with the control.

In addition, data of the first season showed that NAA gave the lowest fruit drop percentage as compared with all other treatments followed by GA_3 and SA application. Whereas, in the second season $CaCl_2$ recorded the lowest fruit drop percentage followed by NAA, CPPU and SA treatments.

Similarly, all treatments significantly decreased the fruit drop percentage after two months from the application date in both seasons in comparison with the control, with, NAA recording the lowest fruit drop percentage as compared with all other treatments in the first season followed by GA_3. However, in the second season all sprayed substances did not significantly differ among each other in their influence on fruit drop.

With regard to the effect of the different treatments on fruit drop percentage after three months from application, the results showed that all treatments significantly decreased the fruit drop percentage in both seasons in comparison with the control. In the first season, NAA recorded the lowest fruit drop percentage followed by GA_3 compared to all other treatments. While, in the second season trees sprayed with CPPU recorded the lowest fruit drop percentage followed by GA_3, BA and SA treatments.

Moreover**,** the effect of the different treatments on the percentage of fruit retention is presented in Table (2). Results of both seasons showed that all treatments significantly increased the fruit retention percent after June drop and at harvest in comparison with the control. Trees sprayed with NAA and GA_3 had the highest percentage of fruit retention after June drop and aharvest followed by CaCl2 and SA treatments in the first season compared with all other treatments. While, in the second season no significant difference was obtained among the treatments after June drop. Fruit retention at harvest was highen with NAA follwed by GA treatments in the first season. Whereas, spraying CPPU resulted in the highest fruit retention at harvest followed by GA_3, BA and SA treatments in the second season.

Tree yield:

Fruit number and weight:

The effect of the different treatments on the tree yield debermined as number and weight (kg) per tree is presented in Table (3).

The data of both seasons showed that all treatments except CPPU in the first season significantly increased the number of fruits per tree as compared with the control. Trees sprayed with NAA and GA_3 had the highest value of fruits number per tree compared to the other treatments in the first season, while, in the second one, trees sprayed with CPPU recorded the highest value of fruits number per tree.

With regard to the effect of the different treatments on the yield expressed as weight of fruits per tree, the data of both seasons showed that all treatments except CPPU in the first season significantly increased fruit weight per tree in comparison with the control .In the first season, spraying NAA and GA3 recorded the highest value of fruit weight per tree compared to the other treatments. While, in the second season, all sprayed substances did not significantly differ among each other in their influence on the weight of fruits per tree. However, spraying BA and CPPU gave the highest values of fruit weight.

In accordance to the reduction of fruit drop and the increase of fruit retention and tree yield obtained in the present study by the different treatments, the obtained results goes in line with those reported by Guillermo *et al.* (2007); Burondkar *et al*. (2009a); Wahdan *et al.* (2011); Bhatt *et al.* (2012); Mandal *et al*. (2012); Nkansah *et al*. (2012); Ahmed *et al*. (2014 and 2015) and El Gammal *et al.* (2015) working on the mango varities: Kent, Alphonso, Succary Abiad, Dashehari, Amrapali, Sukkary and Keitt. Similarly, Al-Qurashi *et al.*(2012) and Kassem *et al.* (2012) found a significant decrease in fruit

drop and yield increase of date palm by spraying NAA, GA3, CPPU, BA and SA. It was previously reported that the deficiency of auxins, gibberellins and cytokinins as well as, high level of inhibitors such as abscissic acid and ethylene appears to be the cause of fruit drop in mango trees (Krisanapook*et al.,* 2000 and Ram, 1983 and 2000). An abscission layer is formed at the site of fruit attachment, when the concentrations of abscissic acid and ethylene increase in the panicle, causing fruit drop .Therefore, this may explain the positive influence of spraying NAA, GA3, BA and CPPU. In the meantime, NAA is well known as inhibitor for abscissic acid and ethylene synthesis (Ram, 1983). Fruit growth after set is dependent in large part on photosynthates supplied by leaves in addition to the increase of the sink ability in fruit through increasing the level of endogenous growth promotters which regulate the mobility of nutrients and photosynthates from the source (leaves) to the sink (fruit) leading to increasing fruit growth and development and decreasing its drop (Emongor and Murr, 2001). Accordingly, (Wasfy, (1995) stated that gibberellins have been found to intensify organ ability to function as nutrient sink and also can increase the biosynthesis of IAA in plant tissue which delays the formation of the separation layer and thus fruit retention. Thus, gibberellins are believed to serve as a mediating process for faster translocation and mobilization of stored metabolites or phothosynthates from source to sink and also play significant role in increasing auxin synthesis in ovaries (Loony *et al*., 1992).

In addition, (Chen, (1983) and Ram (1983) suggested the involvement of cytokinins in the cell division and enlargement of mango fruit by showing the presence of two peaks of cytokineins in activities about 10 days and 50 days after full bloom and thus may cause the fruit growth and decrease its drop.

Meanwhile, cytokinins are reported to alter sink-source relations, is a promising approach to improve yield attributes, and they regulate important physiological parameters that determine biomass formation and distribution via central genes of primary metabolite pathways, including invertases, hexose transporters and key genes of phosphate and nitrogen metabolism and signalling (Schmülling, 2004 and Niederholzer *et al.,* 2006).

Moreover, salicylic acid is found to enhance cell division and the biosynthesis of carbohydrates, to protect trees from biotic and abiotic stresses and inhibit ethylene biosynthesis, which all may lead to strong fruit attachment (Hayat and Ahmad, 2007).

Also, spraying calcium chloride in the present study resulted in positive influence on fruit drop, fruit retention and tree yield indicating that optimizing calcium sprays during fruit growth and development is an important issue in decreasing fruit drop and fruit retention as previously reported by (Rizk-Alla and Meshreki, (2006). Nevertheless, Wang *et al.* (1993) found that ethylene production appeared to be inversely related to the concentration of calcium in the fruit tissue. Also, calcium is known to improve rigidity of cell walls and to obstruct enzymes such as polygalcturo-

nase from reaching their active sites, thereby, retarding the occurrence of abscission zone (Suhardi,1992; Rizk-Alla and Meshreki, 2006).

Table 1. Effect of the spraying treatments on fruit drop percentage of Keitt mango trees in 2014 and 2015 seasons.

Treatments	Fruit drop					
	After one month from treatments		After two months from treatments		After three months from treatments	
	2014	2015	2014	2015	2014	2015
Control	82.33 a	91.99 a	93.77 a	97.35 a	94.53 a	98.09 a
NAA (40 ppm)	62.67 c	84.90 bc	85.39 c	95.61 b	85.70 c	96.27 b
GA_3 (40 ppm)	67.18 bc	89.99 ab	88.21 bc	95.32 b	88.96 bc	95.92 bc
CPPU (10 ppm)	72.35 b	84.49 bc	91.97 ab	94.29 b	92.50 ab	95.17 c
$CaCl_2$ (0.75 %)	72.85 b	83.09 c	89.49 b	95.16 b	90.47 b	96.23 b
BA (40 ppm)	73.11 b	88.35 abc	89.98 ab	94.71 b	90.69 b	96.04 bc
SA (250 ppm)	67.65 bc	84.55 bc	89.44 b	94.91 b	90.11 b	95.78 bc
LSD (0.05).	8.92	6.22	3.89	1.731	3.55	0.98

Means with the same letters for each column are not significantly different at 0.05 level according to LSD method.

Table 2. Effect of the spraying treatments on fruit retention after June drop and at harvest of Keitt mango trees in 2014 and 2015 seasons.

Treatments	Fruit retention			
	After June drop (%)		At harvest(%)	
	2014	2015	2014	2015
Control	6.23 c	2.65 b	5.32 d	1.80 c
NAA (40 ppm)	14.61 a	4.39 a	14.03 a	3.64 b
GA_3 (40 ppm)	11.79 ab	4.68 a	10.61 ab	4.08 ab
CPPU (10 ppm)	8.03 bc	5.93 a	7.05 cd	4.68 a
$CaCl_2$ (0.75 %)	10.51 b	4.84 a	9.39 bc	3.41 b
BA (40 ppm)	10.02 bc	5.29 a	8.92 bc	3.88 ab
SA (250 ppm)	10.56 b	4.72 a	9.22 bc	3.95 ab
LSD (0.05)	**3.90**	**1.70**	**3.27**	**0.92**

Means with the same letters for each column are not significantly different at 0.05 level according to LSD method.

Table 3. Effect of the spraying treatments on the yield as number and weight of Keitt mango trees in 2014 and 2015 seasons.

Treatments	Yield			
	Number of fruits / tree		Weight of fruits / tree (Kg)	
	2014	2015	2014	2015
Control	24.00 c	7.00 c	13.54 c	5.42 b
NAA (40 ppm)	46.00 a	17.00 ab	30.32 a	13.84 a
GA_3 (40 ppm)	39.33 ab	16.33 ab	29.04 a	13.31 a
CPPU (10 ppm)	31.33 bc	21.00 a	21.24 abc	16.43 a
$CaCl_2$ (0.75 %)	38.67 ab	15.33 b	25.48 ab	13.17 a
BA (40 ppm)	36.33 ab	19.33 ab	27.02 ab	17.02a
SA (250 ppm)	34.33 abc	18.33 ab	21.86 abc	12.01a
LSD (0.05)	**11.79**	**4.90**	**9.73**	**5.65**

Means with the same letters for each column are not significantly different at 0.05 level according to LSD method.

Fruit physical characters:

Fruit weight

The effect of the different treatments on fruit weight of both seasons is presented in Table (4). Data obtained in both seasons showed no significant influence of the different treatments on fruit weight.

Fruit firmness

The effect of the different treatments on fruit firmness is presented in Table (4).

In the first season, fruit firmness was not significantly affected by spraying the different compounds when compared with the control. While, in the second season spraying CPPU and SA increased fruit firmness as compared with the untreated control. Additionally, spraying salicylic acid gave the highest value of fruit firmness followed by CPPU in comparison with all other sprayed compounds in the second season.

Peel +pulp weight, peel + pulp weight/fruit weight ratio and seed weight

The effect of the different treatments on fruit peel + pulp weight, fruit peel + pulp weight / fruit weight ratio and seed weight of both seasons is presented in Table (5). The data of both seasons in generals showed that all treatments had not significant effect on these parameters.

Fruit length

The effect of the different treatments on fruit length of both seasons is presented in Table(6).

Data obtained in the first season showed that spraying GA_3 and BA increased significantly fruit length as compared with the control. However, in the second season, only GA_3 significantly increased fruit length in comparison with the control.

Fruit width

The effect of the different treatments on fruit width of both seasons is presented in Table(6).

Results obtained in the first season showed that spraying GA_3 increased significantly fruit width as compared with the control. However, in the second season fruit width was not significantly affected by spraying the different compounds when compared with the control.

Fruit length / width ratio

The effect of the different treatments on fruit length / width ratio of both seasons is presented in Table(6).

Data of both seasons, showed no significant influence of different compounds on fruit length / width ratio except for spraying GA3 in the second season which significantly increased fruit length / width ratio in comparison with the control and all the other treatments.

Similar to the obtained results, Benjawan *et al*. (2006) found that spraying Keaw mango cv. Srisaket with 50 ppm GA_3 increased fruit length but did not affect fruit width and flesh firmness.

Also, Boshra (2007) observed no effect on the fruit physical parameters (fruit weight, length and diameter and stone weight) of Hindi Be Sinnara mangoes after spraying the trees with CPPU, GA_3 and NAA.

In addition, the presented results are in harmony with the findings of Wahdan *et al*. (2011) who reported that spraying mango trees cv. "SuccaryAbiad" with GA_3 increased fruit length, width and fruit firmness and

had no significant effect on fruit shape and fruit pulp weight.

Moreover, increasing mango fruit firmness by SA spray was also indicated by Ahmed *et al.* (2014). They reported that spraying Keitt mango trees with SA caused a significant promotion on fruit quality in terms of increasing fruit firmness. Also, Ahmed *et al*. (2015) working on mango and date palm stated that spraying SA improved the fruit physical characteristics.

Gibberllic acid may maintain fruit firmness by reducing the various physiological activities related to the softening of fruits preventing the synthesis of hydrolytic enzymes such as cellulase which decomposes the cell wall (Davies, 1995).

The role of GA_3 in improving fruit length / width ratio may be attributed to the stimulative influence of this bioregulator on cell extension and /or on cell division resulting in increasing cell elongation as stated by (Marschner, (1986) Pharis and King, (1995) and Sarkar and Ghosh (2005) who indicated that application of GA_3 caused elongation in the primary cells in the young tissues and growth centers. Additionally, Zhang *et al.* (2006) stated that exogenous application of GA_3 increased cell size of the mesocarp by the proliferation of sink demand resulting in enhanced phloem unloading and carbon assimilates metabolism in the fruit.

In the meanwhile, the role of SA in improving the fruit firmness may be due to its influence on the major cell wall degrading enzymes, i.e., cellulase, polygalacturonase and xylanase which were found to be decreased in the presence of salicylic acid (Srivastava and Dwivedi 2000). In this respect, Sayyari *et al*.(2009) also reported that salicylic acid decreased firmness loss by delaying ethylene production.

Fruit chemical characters:

Total soluble solids (TSS)

The effect of the different treatments on total soluble solids (TSS) of both seasons is presented in Table (7). Results obtained in both seasons showed that fruit total soluble solids content was not significantly affected by any of the spraying treatments.

Fruit acidity

The effect of the different treatments on fruit acidity of both seasons is presented in Table (7).

Results of the first season, showed that fruit acidity was not significantly affected by any of the spraying treatments. Whereas, in the second season spraying NAA, CPPU, $CaCl_2$ and BA significantly decreased fruit acidity content in comparison with the control. The minimum values were obtained by NAA, $CaCl_2$.

TSS /acidity ratio

Effect of the different treatments on TSS / acidity ratio of both seasons is presented in Table(7).

The data obtained in the first season showed no significant influence of all treatments on fruit TSS / acidity ratio. However, in the second season spraying NAA and $CaCl_2$ resulted in significantly higher TSS / acidity ratio than the control without significant difference between them.

Total, reducing and non - reducing sugars

The effect of the different treatments on total, reducing and non

- reducing sugars of both seasons is presented in Table(8).

In general, data obtained in both seasons showed no significant influence of the different treatments on fruit reducing, non-reducing and total sugars content.

Vitamin C, carotenes and soluble phenols content

The effect of the different treatments on vitamin C, carotenes and soluble phenols content of both seasons is presented in Table (9).

Results of both seasons indicated no significant effect of the different treatments on fruit vitamin C, carotenes and soluble phenols content as compared with the control except that spraying SA resulted in significant higher V.C content than the control in the first season.

It is obvious from the obtained results that the fruit chemical characters were not generally influenced which goes on line with other studies indicating no significant influence of the different sprayed compounds on the mango fruit chemical properties; Benjawan *et al*. (2006) found that spraying keaw mango cv. Srisaket with 50 ppm GA_3 had no significant effect on TSS. Also, Boshra (2007) observed no effect on fruit TSS, acidity and vitamin C of Hindi Be Sinnara mangoes after spraying the trees with CPPU, GA_3 and NAA alone or in double combinations 14 days after blooming. Also, Burondkar *et al*. (2009) found that Alphonso mango fruit acidity content was not affected by treatments with the growth regulators.

However, fruit acidity content in the present study decreased by NAA, CPPU, $CaCl_2$ and BA. These results are in harmony with these obtained by Gupta and who reported a significant decrease in mango fruit acidity by spraying NAA.

Also, spraying SA in this study resulted in a significant increase in fruit V.C content and was also obtained by Ahmed *et al*. (2015) who indicated that spraying Sukkary mango trees with salicylic acid was very effective in enhancing vitamin C content and decreasing total acidity. Salicylic acid enhance the resistance of fruits against pathogens, especially at the earlier maturity stage, as well as in handling harvested fruits as a food additive to delay some fruit ripening processes (Cao *et al.,* 2006).

Table 4. Effect of the spraying treatments on fruit weight and fruit firmness of Keitt mango trees in 2014 and 2015 seasons.

Treatments	Fruit weight (g)		Fruit firmness (kg/cm^2)	
	2014	2015	2014	2015
Control	561 a	882 a	1.60 a	1.27 c
NAA (40 ppm)	660 a	810 a	1.65 a	1.45 bc
GA_3 (40 ppm)	740 a	828 a	1.65 a	1.64 bc
CPPU (10 ppm)	684 a	792 a	1.88 a	1.84 ab
$CaCl_2$ (0.75 %)	666 a	874 a	1.96 a	1.49 bc
BA (40 ppm)	725 a	875 a	1.65 a	1.67 bc
SA (250 ppm)	632 a	659 a	1.66 a	2.18 a
LSD (0.05)	191	226	0.57	0.36

Means with the same letters for each column are not significantly different at 0.05 level according to LSD method.

Table 5. Effect of the spraying treatments on peel + pulp weight, peel + pulp weight / fruit weight ratio and seed weight of Keitt mango trees in 2014 and 2015 seasons.

Treatments	Peel + pulp weight (g)		Peel + pulp weight / fruit weight ratio		Seed weight (g)	
	2014	2015	2014	2015	2014	2015
Control	510.96 a	821.20 a	91.04 a	92.72 a	50.13 a	60.37 ab
NAA (40 ppm)	601.56 a	750.07 a	91.11 a	92.57 a	58.77 a	60.37ab
GA_3 (40 ppm)	681.10 a	767.07 a	92.10 a	92.60 a	58.53 a	60.87ab
CPPU (10 ppm)	629.23 a	733.76 a	91.91a	92.61 a	54.60 a	58.57 ab
$CaCl_2$ (0.75 %)	616.13 a	808.53 a	92.46 a	92.33 a	50.43 a	65.23 a
BA (40 ppm)	667.86 a	814.56 a	92.11 a	92.72 a	56.83 a	60.73 ab
SA (250 ppm)	580.53 a	609.33 a	91.91 a	92.48 a	51.17 a	49.40 b
LSD (0.05).	181.07	223.42	1.62	2.31	14.35	13.35

Means with the same letters for each column are not significantly different at 0.05 level according to LSD method.

Table 6. Effect of the spraying treatments on fruit length and fruit width and fruit length / width of Keitt mango in 2014 and 2015 seasons.

Treatments	Fruit length (cm)		Fruit width (cm)		Fruit length / Width	
	2014	2015	2014	2015	2014	2015
Control	11.50 c	13.56 b	8.63 b	10.16 a	1.33 a	1.35 b
NAA (40 ppm)	12.83 abc	14.11 ab	9.37 ab	10.44a	1.37a	1.35 b
GA_3 (40 ppm)	13.87a	15.39a	10.03a	10.33a	1.38a	1.49 a
CPPU (10 ppm)	12.73abc	14.24 ab	9.43 ab	10.47 a	1.35 a	1.37 b
$CaCl_2$ (0.75 %)	12.70abc	14.15 ab	9.63 ab	10.22a	1.32a	1.38 b
BA (40 ppm)	13.17 ab	14.59 ab	9.57 ab	10.64 a	1.37a	1.37 b
SA (250 ppm)	12.27 bc	13.33 b	8.90 ab	10.17 a	1.37a	1.32 b
LSD (0.05)	1.44	1.29	1.25	0.74	0.12	0.10

Means with the same letters for each column are not significantly different at 0.05 level according to LSD method.

Table 7. Effect of the spraying treatments on TSS, acidity and TSS / acidity content of Keitt mango trees in 2014 and 2015 seasons.

Treatments	TSS (%)		Acidity (%)		TSS / acidity	
	2014	2015	2014	2015	2014	2015
Control	17.02 a	18.38 abc	0.306 a	0.459 a	59.29a	40.52b
NAA (40 ppm)	17.84a	19.28a	0.289a	0.339c	63.54 a	56.77a
GA_3 (40 ppm)	17.53a	19.22ab	0.232 a	0.432ab	76.75a	46.84 ab
CPPU (10 ppm)	16.66a	17.68c	0.287 a	0.359bc	61.56a	49.69ab
$CaCl_2$ (0.75 %)	18.17a	18.86abc	0.278 a	0.338 c	65.99a	55.80a
BA (40 ppm)	17.60 a	17.91bc	0.248 a	0.362bc	74.27a	49.60ab
SA (250 ppm)	16.97a	18.57 abc	0.227 a	0.408abc	77.28a	46.96 ab
LSD (0.05).	2.27	1.34	0.053	0.091	23.14	11.45

Means with the same letters for each column are not significantly different at 0.05 level according to LSD method.

Table 8. Effect of the spraying treatments on fruit total, reducing and non-reducing sugars of Keitt mango trees in 2014 and 2015 seasons.

Treatments	Total sugars (%)		Reducing sugars (%)		Non-reducing sugars (%)	
	2014	2015	2014	2015	2014	2015
Control	16.40a	17.00 a	5.82 a	5.97a	10.59 a	11.03 a
NAA (40 ppm)	17.25a	17.64 a	5.87 a	5.93a	11.38 a	11.70 a
GA_3 (40 ppm)	16.42a	17.71 a	5.33 b	5.99 a	11.19 a	11.72 a
CPPU (10 ppm)	16.47a	16.65 a	5.75 a	5.72a	10.84 a	10.93 a
$CaCl_2$ (0.75 %)	17.21a	17.26 a	5.77 a	5.34 a	11.44 a	11.92 a
BA (40 ppm)	16.71a	16.89 a	5.74 a	5.86 a	10.97 a	11.04 a
SA (250 ppm)	16.16a	17.58 a	5.54 ab	5.94 a	10.52 a	11.65 a
LSD (0.05)	2.22	1.60	0.34	0.69	2.17	1.02

Means with the same letters for each column are not significantly different at 0.05 level according to LSD method.

Table 9. Effect of the spraying treatments on V.C., carotenes and total phenols content of Keitt mango trees in 2014 and 2015 seasons.

Treatments	V.C. (mg/100 ml)		Carotenes (mg/100g)		Total phenols (%)	
	2014	2015	2014	2015	2014	2015
Control	28.59 b	34.50 ab	5.85 a	4.94 a	0.089 a	0.131 a
NAA (40 ppm)	27.55 b	28.44 c	5.08 a	4.98 a	0.094 a	0.094 a
GA_3 (40 ppm)	29.27 ab	39.00 a	5.78 a	4.89 a	0.092 a	0.079 a
CPPU (10 ppm)	28.12 b	34.85 ab	5.50 a	4.77 a	0.092 a	0.088 a
$CaCl_2$ (0.75 %)	28.81 ab	31.70 bc	5.79 a	4.89 a	0.091 a	0.079 a
BA (40 ppm)	25.97 b	33.65 abc	5.56 a	4.92 a	0.087 a	0.079 a
SA (250 ppm)	33.55 a	38.40 a	5.61 a	5.12 a	0.091 a	0.109 a
LSD (0.05)	4.49	5.65	0.92	0.60	0.008	0.053

Means with the same letters for each column are not significantly different at 0.05 level according to LSD method.

Conclusion

From the above mentioned results it was concluded that all sprayed treatments affected fruit drop, retention and tree yield. However, trees sprayed with NAA, GA_3, CPPU and BA were considered the best and effective in decreasing fruit drop and increasing fruit retention and tree yield. Moreover, spraying GA_3 was the best in increasing fruit length, width and length / width ratio. Spraying SA and CPPU improved fruit firmness in the first season only. In the meantime, spraying SA resulted higher values of V.C content. Spraying NAA and CaC_{l2} had positive influence on fruit acidity and TSS/ acidity ratio in comparison with the control.

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تأثير الرش ببعض منظمات النمو وكلوريد الكالسيوم على تساقط الثمار والمحصول وجوده ثمار المانجو الكيت

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الملخص

أجريت هذه الدراسة خلال عامي ٢٠١٤ و ٢٠١٥ على أشجار مانجو عمرها ٨ سنوات لدراسة تأثير رش كل من نفثالين أستيك اسيد ٤٠ جزء في المليون، جبريلك أسيد ٤٠ جزء في المليون، سيتوفيكس (٢- كلورو – ٤- بيريدل) ن فينيلوريا (CPPU) ١٠ جزء في المليون، وكلوريد الكالسيوم ٠,٧٥% ، وبينزايل أدينين ٤٠ جزء في المليون، وسلسليك أسيد ٢٥٠ جزء في المليون.

بعد عقد الثمار على تساقط الثمار والمحصول وجودة الثمار في أشجار المانجو الكيت.

الأشجار كانت مزروعة على مسافات (٢×٣م) ونامية في أرض رملية في مزرعة خاصة في منطقة إدكو – محافظة البحيرة – مصر.

تصميم التجربة قطاعات عشوائية كاملة. (RCPD) الأشجار رشت مرتين بعد عقد الثمار وبعد ٣٠ يوم من العقد.

النتائج أوضحت أن النسبة المئوية لتساقط الثمار بعد شهر، وشهرين، وثلاثة أشهر من تاريخ المعاملة كانت منخفضة معنويًا ونسبة الثمار المتبقية والمحصول لكل شجرة ازداد بكل المواد المرشوشة بالمقارنة بالكنترول في كلا الموسمين.

عمومًا الرش بـ NAA, GA_3, CPPU و BA كانت الأفضل وأثرت في تقليل تساقط الثمار وزيادة بقاء الثمار ومحصول الأشجار.

رش الجبريليك أسيد والسلسليك أسيد و سيتوفيكس (٢- كلورو – ٤- بيريدل) ن فينيلوريا حسنت بعض صفات الجودة الفيزيائية للثمار بالمقارنة بالكنترول.

في نفس الوقت، رش سلسليك أسيد والنفثالين أستيك أسيد وكلوريد الكالسيوم كان لها تأثير إيجابي على الصفات الكيميائية للثمار بالمقارنة بالكنترول.