

Effect of Growth Regulator, Antioxidant and Application Date on Fruiting and Fruit Quality of Mango Trees cv. Keitt

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Abstract: This study was conducted during two consecutive seasons of 2013 and 2014 at private orchard at El Tall El Kbeer region, Ismailia Governorate Egypt. The effects of growth regulator i.e. GA₃ at 20 and 40 ppm, NAA at 25 and 50 ppm and citric acid as antioxidant at 400 and 800 ppm and two application date i.e. the first date was done at full bloom and one month later and the second date was done at full bloom and two months later were studied on fruiting and fruit quality of Keitt mango trees. Resulted showed that NAA treatment surpassed GA₃ and citric acid in enhancing the previously mentioned studied traits especially 50 ppm NAA treatment in this concern. Moreover, application date results indicated that foliar sprays application at second date enhanced the studied fruit set and fruit retention percentage, yield and fruit quality traits. Consequently, it is preferable to spray NAA at 50 ppm at full bloom and two months later enhance fruiting and fruit quality of Keitt mango trees.

Key words: Keitt mango; GA₃; NAA; citric acid; application date; yield; fruit quality.

I. Introduction

Mango (*Mangifera indica*, L.) is one of the important and most popular fruit species in Egypt. Keitt mangoes cv. grown in new reclaimed soil especially sandy soil conditions suffer from low productivity due to low fruit set and excessive fruit drop percentage at different fruit growth stages. Low productivity of crops could be a result of various factors including genetically, environmental, cultural and hormonal factors (Sahoo et al., 2014). The mango fruit drop accounts for over 90% loss of fruitlets. It is heavy during first three weeks of fruit set when the rate of fruit development is rapid and it continues up to the 5th week (Ram, 1992; Bains et al., 1997 and Sigh et al., 2005). There are several causes of fruit drop including unfavorable climatic conditions, poor fruit set, competition between developing fruitlets, drought or lack of irrigation, nutrient deficiency, incidence of serious diseases and pests (Majumder and Sharma, 1990). Hormones deficiency that play a major role in fruit growth and fruit drop of mango (Ram, 1992 and Bains et al., 1997). Moreover, deficiency of auxins, gibberellins and cytokinins coupled with a high level of growth inhibitors i.e. abscissic acid and ethylene cause fruit drop (Ram, 1983). Foliar sprays of growth regulators (NAA and GA₃) could be used as one of these horticultural practices that reduce fruit drop enhance yield and fruit quality of mangoes (Anila and Radha, 2003). Chattha et al. (1999) indicated that NAA application induced high positive effect in reducing fruit drop. Moreover, NAA application reduced flowers drop, and gave high flowers retention and increased yield as well as improved fruit quality of mango (Hairdy et al., 1997 and Vejendla et al., 2008). Furthermore, foliar spray of NAA and GA₃ enhanced yield and fruit quality as well as reduced fruit drop of mango trees (Muarya and Singh, 1981 and Nkansah et al., 2012). Antioxidants play an important role in stress tolerance of crop plants which help plants to ameliorate the bad effect of stress. Organic acids as antioxidants (such as citric acid) play an important role in plant metabolism (Mansour et al., 2008 and Maksoud et al., 2009). Citric acid chelating these free radicals and protecting plant from injury could result in prolonging the shelf life of plant cells and improving growth characters (Rao et al., 2000). Citric acid has auxinic action and positive effect on flowering and fruiting and used instead of synthetic auxins and other chemicals for enhancing growth and fruiting of fruit trees (Maksoud et al., 2009). Moreover, the use of citric acid is very important for protecting environmental pollution. On the other hand, Ahmed and Abdelaal (2007) on Anna apple, Mansour et al. (2008) on Le- Conte pear and Mansour et al. (2010) on four mango cultivars, they mentioned that citric acid treatment improved yield and fruit quality parameters of the aforementioned fruit species. Therefore, the purpose of this work is to evaluate the effect of NAA, GA₃, citric acid foliar spray and two application dates on fruiting and fruit quality of mango trees cv. Keitt.

II. Material And Methods

This study was carried out during two successive seasons of 2013 and 2014 at private orchard at El Tall El Kbeer region, Ismailia Governorate Egypt. Nine years old Keitt mango trees (*Mangifera indica*, L) budded on mango seedling rootstocks, grown in sandy soil and spaced 5 x 5 m apart subjected to drip irrigation system. Physical and chemical analyses of the experimental soil are shown in Table, 1. Eighty four trees healthy, nearly

uniform in shape and size and productivity and received the same horticulture practices were subjected to this study.

Table 1. Analysis of orchard experimental soil at Ismailia Governorate, Egypt.

Soil Depth (cm)	Texture class	Organic matter (%)	CaCO ₃	PH Soil past	E.C. (dSm ⁻¹)	Soluble cations (mequiv./l)				soluble anions (mequiv./l)			
						Ca ²⁺	K ⁺	Na ⁺	Mg ²⁺	Cl ⁻	SO ₄ ²⁻	HCO ₃ ⁻	CO ₃ ²⁻
0-30	Sand	0.20	5.91	7.7	0.70	3.10	0.10	2.61	1.12	4.06	1.53	1.33	--
30-60	Sand	0.19	3.84	7.7	0.80	3.07	0.20	3.32	1.33	3.77	3.34	0.81	--

The present study is a factorial experiment with two factors.

- a- The first factor consisted of seven spray treatments i.e. a- Control (tap water), b- GA₃ at 20 and 40 ppm, c- Citric acid at 400 and 800 ppm, d- NAA (naphthaleneacetic acid) at 25 and 50 ppm.
- b- The second one involved two application dates of the tested treatments, the first date was done at full bloom and one month later (1st date) and the second date was done at full bloom and two months later (2nd date), meanwhile, the control trees were sprayed with tap water at the previously mentioned dates. Tween-20 was added at 0.1% as a surfactant to spray solution including the control "tap water". Spraying was carried out using compression sprayers (5L solution/tree) at the previously mentioned dates.

This study was designed as a factorial experiment with two factors arranged in a randomized complete block design with three replicates for each treatment and each replicate was represented by two trees.

Response of Keitt mango trees to the tested treatments and their combinations was evaluated through the following determinations.

2.1. Fruit set and fruit retention

Number of fruitlets per panicle was counted after 15 days of full bloom to determine the initial number of set fruitlets per panicle. The initial fruit set was calculated as a percentage. After recording the initial fruit set, number of fruits per panicle was recorded at mature stage (a week before harvest). The percentage of retained fruits at harvest time was calculated.

2.2. Yield (kg/tree) and No. of fruits/tree

In each season, at harvest time (October, 3th), number of fruits per each treated tree was counted and reported then yield (kg/tree) was weighed and recorded.

2.3. Fruit quality

Five ripen fruits were taken at harvest from each treated tree for determination of the following physical and chemical properties i.e. fruit weight (g), seed weight (g), peel weight (g), pulp fruit percentage. Total soluble solids (T.S.S.) was determined by Hand refractometer. Percentage of total acidity as g citric acid / 100 g F.Wt., total sugars %, and ascorbic acid (mg ascorbic acid/100 ml juice) according to A.O.A.C. (1995).

Statistical analysis

The obtained data in 2013 and 2014 seasons were subjected to analysis of variance according to Clarke and Kempson (1997). Means were differentiated using Range test at the 0.05 level (Duncan, 1955).

III. Results And Discussion

3.1. Fruit set and fruit retention

3.1.1. Fruit set (%)

Table, 2 illustrates that all GA₃, citric acid and NAA treatments induced high positive effect on fruit set percentage as compared with the control treatment in both seasons. Generally, 50 ppm NAA treatment proved to be the superior treatment in this concern.

Moreover, application date showed that second date exerted a pronounced positive effect on fruit set percentage than the first date in 2013 season. Meanwhile, application date did not show any significant effect on fruit set percentage in 2014 season.

Furthermore, the interaction between the two tested factors showed that combinations of 50 ppm NAA treatment applied in the second date in 2013 season and 25 and 50 ppm NAA treatments applied in the first and/or second dates in 2014 season gave similar and higher positive effect on fruit set percentage as compared with the control treatment in this respect. Other combinations exerted an intermediate values in this sphere.

Table 2. Effect of GA₃, citric acid, NAA and application date on fruit set percentage of Keitt mango trees (2013 and 2014 seasons).

Treatments	Fruit set (%)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	7.78 g	8.12 g	7.95 G	6.42 e	5.75 e	6.08 D
GA ₃ at 20 ppm	8.78 f	9.08 f	8.93 F	6.86 de	6.89 de	6.87 CD
GA ₃ at 40 ppm	9.18 f	9.77 e	9.47 E	6.89 de	7.25 cde	7.07 CD
Citric acid at 400 ppm	10.11 e	10.06 e	10.08 D	8.43 bcd	8.87 abc	8.65 BC
Citric acid at 800 ppm	10.94 d	10.81 d	10.87 C	8.85 abc	9.26 ab	9.05 AB
NAA at 25 ppm	11.22 cd	11.67 bc	11.44 B	9.26 ab	10.36 a	9.81 AB
NAA at 50 ppm	12.10 ab	12.19 a	12.14 A	10.43 a	10.71 a	10.57 A
Mean	10.02 B	10.24 A		8.16 A	8.44 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

3.1.2. Fruit retention (%)

Table, 3 reveals that all tested treatments exerted high enhancing effect on retained fruit percentage as compared with the control treatment in both seasons. Generally, 50 ppm NAA treatment proved to be the superior treatment in this respect.

Furthermore, application date had no remarkable effect on retained fruit percentage in both seasons.

On the other hand, the combinations of 50 ppm NAA treatment applied in the second date in the 2013 season and 25 and 50 ppm NAA treatment applied in the both dates in 2014 season gave similar and higher positive effect on fruit retained percentage as compared with the control in this concern. Other combinations gave an intermediate values in this respect.

3.2. Yield (kg/tree) and No. of fruits/tree

3.2.1. No. of fruits/tree

Table, 4 shows that all GA₃, citric acid and NAA treated tree produced higher number of fruits per tree as compared with the control treatment in both seasons. Generally, 800 ppm citric acid, 25 ppm NAA and 50 ppm NAA treatments exerted similar and higher pronounced effect on number of fruits per tree and proved to be the superior treatments in this concern.

Moreover, reported date of application date showed that second application date surpassed the first one in this respect in both seasons.

In addition, the combination of 50 ppm NAA treatment applied in the second date scored 26.47 and 29.60 fruits/tree against 23.21 and 24.84 fruits/tree for control treatment in the first and the second seasons respectively. Other combinations gave an intermediate values in this concern.

Table 3. Effect of GA₃, citric acid, NAA and application date on fruit retained percentage of Keitt mango trees (2013 and 2014 seasons).

Treatments	Fruit retention (%)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	2.00 i	2.01 i	2.01 G	1.60 h	1.62 h	1.61 F
GA ₃ at 20 ppm	2.21 h	2.26 gh	2.23 F	1.64 g	1.62 gh	1.63 F
GA ₃ at 40 ppm	2.34 ef	2.31 fg	2.32 E	1.68 f	1.69 f	1.68 E
Citric acid at 400 ppm	2.46 d	2.38 e	2.42 D	1.71 e	1.72 e	1.71 D
Citric acid at 800 ppm	2.49 d	2.48 d	2.48 C	1.74 d	1.75 d	1.74 C
NAA at 25 ppm	2.59 c	2.64 c	2.61 B	1.79 c	1.81 b	1.80 B
NAA at 50 ppm	2.78 b	2.91 a	2.84 A	1.85 a	1.86 a	1.85 A
Mean	2.41 A	2.42 A		1.72 A	1.73 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

3.2.2. Yield kg/tree

Table, 5 illustrates that all tested treatments succeeded in improving yield (kg/tree) as compared with control treatment in both seasons. Briefly, 50 ppm NAA treatment scored 20.1 and 16.7 kg/tree as compared with 10.9 and 9.9 kg/tree for the control treatment in 2013 and 2014 seasons, respectively.

Table 4. Effect of GA₃, citric acid, NAA and application date on number of fruits per tree of Keitt mango trees (2013 and 2014 seasons).

Treatments	No. of fruits					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	23.21 j	23.23 j	23.22 D	24.84 f	25.71 ef	25.27 B
GA ₃ at 20 ppm	23.84 i	25.19 i	24.51 C	26.03 def	26.86 bcdef	26.45 AB
GA ₃ at 40 ppm	24.43 h	25.55 h	24.99 C	26.73 cdef	27.56 bcde	27.14 AB
Citric acid at 400 ppm	25.47 g	25.78 d	25.62 B	26.35 def	27.99 abcd	27.17 AB
Citric acid at 800 ppm	26.25 f	26.74 c	26.50 A	26.51 def	28.66 abc	27.58 A
NAA at 25 ppm	26.30 e	26.91 b	26.60 A	25.85 ef	28.83 ab	27.34 A
NAA at 50 ppm	26.95 d	26.47 a	26.71 A	25.71 ef	29.60 a	27.66 A
Mean	25.21 B	25.70 A		26.00 B	27.89 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

Table 5. Effect of GA₃, citric acid, NAA and application date on yield of Keitt mango trees (2013 and 2014 seasons).

Treatments	Yield (kg)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	10.9 m	11.0 m	10.9 G	9.8 k	10.1 k	9.9 G
GA ₃ at 20 ppm	12.0 l	13.0 k	12.5 F	10.8 j	11.3 i	11.0 F
GA ₃ at 40 ppm	14.5 j	15.5 i	15.0 E	12.8 h	11.9 g	11.8 E
Citric acid at 400 ppm	15.5 h	17.5 f	16.5 D	12.6 g	14.8 e	13.7 D
Citric acid at 800 ppm	17.0 g	19.0 d	18.0 C	13.1 f	16.9 c	15.0 C
NAA at 25 ppm	18.5 e	19.4 b	18.9 B	13.8 d	18.0 b	15.9 B
NAA at 50 ppm	19.5 c	20.7 a	20.1 A	14.8 b	18.8 a	16.7 A
Mean	15.4 B	16.5 A		12.3 B	14.5 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

Moreover, application date showed that the second date enhanced yield (kg/tree) and scored 16.5 and 14.5 kg/tree against 15.4 and 12.3 kg/tree for control treatment in the first date in the first and the second seasons, respectively.

On the other hand, the interaction between the two tested factors indicated that combination of 50 ppm NAA treatment applied in the second date induced high positive effect on yield and scored 20.7 and 18.8 kg/tree as compared with 10.9 and 9.8 kg/ tree for control treatment in the 2013 and 2014 seasons respectively. Other combinations gave an intermediate values in this concern.

The enhancement effect of NAA sprays on fruit set and fruit retention percentage, number of fruit per tree and yield may be due to Auxin is well known as inhibitors for abscissic acid and ethylene which cause fruit drop (Ram, 1983). The use of NAA may regulate fruit set in many fruit crops and spraying mango trees with NAA increased fruit set and fruit retention percentages (Oksher et al., 1980 and Singh and Ram, 1983). Which reflected on increased of No. of fruits per tree and yield.

The obtained results of NAA regarding their positive effect on fruit set, fruit retention, number of fruits per tree and yield are in harmony with the findings of Chattha et al. (1999) who indicated that NAA application induced high positive effect on reducing fruit drop. Moreover, NAA application reduced flowers drop, and it gave high flowers retention and increased yield of mango (Hairdy et al., 1997; Vejendla et al., 2008 and Nkansah et al., 2012).

The enhancement effect of citric acid on fruit set, fruit retention, number of fruit per tree and yield are mainly through the fact that citric acid plays an important role in plant metabolism (Singh et al., 2010). Moreover, citric acid chelating these free radicals and protecting plant from injury could result in prolonging the shelf life of plant cells and improving growth characters (Rao et al., 2000). Also, citric acid has auxinic action and positive effect on flowering and fruiting and used instead of synthetic auxins and other chemicals for enhancing growth and fruiting of fruit trees (Maksoud et al., 2009) which reflected on improved flowering and fruiting tree.

The obtained results of citric acid regarding its positive effect on fruit set, fruit retention, number of fruit per tree and yield are in agreement with the findings of Ahmed and Abdelaal (2007) on Anna apple, Mansour et al. (2008) on Le- Conte pear and Mansour et al. (2010) on four mango cultivars. They mentioned that citric acid treatment improved fruit set and yield of the aforementioned fruit species.

The enhanced effect of GA₃ treatment on fruit set, fruit retention, number of fruit per tree and yield may be due to the role of GA₃ through multiplying and to lengthily the meristem cells, which induced positive effect on reducing fruit drop and increase number of fruits per tree and yield kg/tree (Sarkar and Ghosh, 2005).

The obtained results of GA₃ regarding its positive effect on fruit set, fruit retention, number of fruit per tree and yield are in harmony with the findings of Muarya and Singh (1981) who reported that foliar spray of GA₃ and NAA enhanced yield and reduced fruit drop of mango trees. Moreover, Saski and Utsunomiya (2002) who mentioned that spraying mango trees with GA₃ plus CPPU enhanced fruit retention. Furthermore, foliar spray of growth regulators GA₃ enhanced yield of mangoes (Anila and Radha, 2003). Furthermore, Sarkar and Ghosh (2005) indicated that the GA₃sprays increased yield of mango fruits.

3.3. Fruit quality

3.3.1. Fruit physical properties

3.3.1.1. Fruit weight (g)

Table, 6 indicates that all GA₃, citric acid and NAA treatments increased fruit weight as compared with control treatment in both seasons. Generally, 50 ppm NAA treatment produced the heaviest fruit 752.3 and 614.5 g against 471.0 and 393.0 g for the control treatment in the 2013 and 2014 seasons, respectively.

Furthermore, the second application date surpassed the first application date in improving fruit weight in both seasons.

Moreover, the combination of 50 ppm NAA treatment applied in the second date record the higher values of fruit weight 781.6 and 637.0 g against 649.0 and 391.0 g for control treatment in the first application date in 2013 and 2014 seasons, respectively. Other combinations gave an intermediate values in this sphere.

Table 6. Effect of GA₃, citric acid, NAA and application date on fruit weight of Keitt mango trees (2013 and 2014 seasons).

Treatments	Fruit weight (g)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	469.0 j	473.0 j	471.0 G	391.0 k	395.0 k	393.0 G
GA ₃ at 20 ppm	503.0 i	515.6 h	509.3 F	410.0 i	420.0 i	415.0 F
GA ₃ at 40 ppm	593.0 g	606.0 f	599.5 E	431.0 h	431.6 h	431.3 E
Citric acid at 400 ppm	608.0 f	678.6 d	643.3 D	485.0 g	530.0 e	507.5 D
Citric acid at 800 ppm	647.0 e	710.0 c	678.5 C	510.0 f	591.0 c	550.5 C
NAA at 25 ppm	703.0 c	723.0 b	713.0 B	560.0 d	625.0 b	592.5 B
NAA at 50 ppm	723.0 b	781.6 a	752.3 A	592.0 c	637.0 a	614.5 A
Mean	606.6 B	641.1 A		482.7 B	518.5 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

3.3.1.2. Seed weight (g)

Table, 7 reveals that all tested treatments exerted high positive effect on seed weight as compared with the control treatment in both seasons. Generally, 50 ppm NAA treatment proved to be the superior treatment in this respect.

Table 7. Effect of GA₃, citric acid, NAA and application date on seed weight of Keitt mango trees (2013 and 2014 seasons).

Treatments	Seed weight (g)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	50.9 m	51.1 m	51.0 G	51.7 k	52.1 k	51.9 G
GA ₃ at 20 ppm	53.2 l	52.7 k	53.5 F	53.4 j	53.5 i	53.5 F
GA ₃ at 40 ppm	54.2 j	54.6 i	54.4 E	54.1 h	54.1 g	54.1 E
Citric acid at 400 ppm	55.4 g	55.3 h	55.4 D	55.1 f	55.2 e	55.1 D
Citric acid at 800 ppm	56.2 f	56.4 e	56.3 C	55.8 d	55.9 c	55.8 C
NAA at 25 ppm	57.1 d	57.4 c	57.2 B	56.1 b	56.1 b	56.1 B
NAA at 50 ppm	58.0 b	58.1 a	58.0 A	56.3 a	56.3 a	56.3 A
Mean	55.0 B	55.2 A		54.6 B	54.8 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

Furthermore, application date showed that the second application date surpassed the analogous one (1st application date) in enhancing seed weight in both seasons.

On the other hand, the interaction between the two tested factors indicated that combinations of 50 ppm NAA treatment applied in the second date in 2013 season and 25 and 50 ppm NAA treatment applied in the both dates in 2014 season gave similar and higher positive effect on seed weight as compared with the control in this concern. Other combinations gave an intermediate values in this respect.

3.3.1.3. Peel weight (g)

Table, 8 illustrates that all GA₃, citric acid and NAA treatments induced high positive effect on peel weight as compared with the control treatment in both seasons. Generally, 50 ppm NAA treatment in the 2013 season and 25 and 50 NAA treatments in second season exerted a similar and high positive effect on peel weight than other tested treatments in this concern.

Moreover, the second application date exerted pronounced effect on peel weight than the first application date in 2013 season. Meanwhile, application date did not show any effect on peel weight in 2014 season.

Furthermore, the interaction between the two tested factors showed that combinations of 50 ppm NAA treatment applied in the first date in 2013 season and 50 ppm NAA treatment applied in the second date in 2014 season gave high positive effect on peel weight as compared with the control treatment in this respect. Other combinations exerted an intermediate values in this sphere.

Table 8. Effect of GA₃, citric acid, NAA and application date on peel weight of Keitt mango trees (2013 and 2014 seasons).

Treatments	Peel weight (g)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	75.23 l	75.25 l	75.24 G	73.20 f	73.23 f	73.22 D
GA ₃ at 20 ppm	76.12 k	76.38 j	76.25 F	73.29 ef	73.30 def	73.29 CD
GA ₃ at 40 ppm	76.66 h	76.57 i	76.61 E	73.31 def	73.38 cdef	73.34 BCD
Citric acid at 400 ppm	76.98 e	76.78 g	76.88 D	73.42 cdef	73.75 ab	73.58 AB
Citric acid at 800 ppm	77.24 c	76.91 f	77.07 C	73.53 bcde	73.59 abcd	73.56 ABC
NAA at 25 ppm	77.56 b	77.10 d	77.33 B	73.64 abc	73.71 ab	73.67 A
NAA at 50 ppm	78.00 a	77.25 c	77.62 A	73.81 ab	73.88 a	73.84 A
Mean	76.83 A	76.60 B		73.40 A	73.50 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

3.3.1.4. Pulp/fruit (%)

Table, 9 shows that all tested treatments induced high positive effect on pulp/fruit percentage as compared with the control treatment in both seasons. Generally, 50 ppm NAA treatment exerted high positive effect and record 81.92 and 78.78 % against 73.25 and 68.21 % for control treatment in 2013 and 2014 seasons, respectively.

Table 9. Effect of GA₃, citric acid, NAA and application date on pulp/fruit of Keitt mango trees (2013 and 2014 seasons).

Treatments	Pulp/fruit (%)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	73.25 j	73.28 j	73.28 G	68.21 j	68.24 j	68.23 G
GA ₃ at 20 ppm	74.27 i	74.75 h	74.51 F	69.07 i	69.78 h	69.43 F
GA ₃ at 40 ppm	77.91 g	78.34 f	78.12 E	70.42 g	70.44 g	70.43 E
Citric acid at 400 ppm	78.21 f	80.52 d	79.36 D	73.48 f	75.72 d	74.60 D
Citric acid at 800 ppm	79.36 e	81.21 b	80.28 C	74.62 e	78.08 b	76.35 C
NAA at 25 ppm	80.83 c	81.38 b	81.11 B	76.82 c	79.22 a	78.02 B
NAA at 50 ppm	81.18 b	82.67 a	81.92 A	78.01 b	79.55 a	78.78 A
Mean	77.86 B	78.88 A		72.95 B	74.73 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

Moreover, the second application date exerted high positive effect on pulp/fruit percentage than the first application date in 2013 season. However, application date had no effect on pulp/fruit percentage in 2014 season.

Furthermore, the interaction between the two tested factors indicated that combinations of 50 ppm NAA treatment applied in the second date in 2013 season and 25 and 50 ppm NAA treatments applied in the second date in 2014 season gave similar and higher positive effect on pulp/fruit percentage as compared with the control treatment. Other combinations exerted an intermediate values in this respect.

3.3.2. Fruit chemical properties

3.3.2.1. T.S.S. (%)

Table, 10 indicates that all GA₃, citric acid and NAA treatments gave higher positive effect on TSS (%) as compared with control treatment in both seasons. Generally, 50 ppm NAA treatment enhanced TSS and record 21.50 and 18.40 % against 16.95 and 16.01 % for control in the 2013 and 2014 seasons, respectively.

Furthermore, the second application date surpassed the analogous one in this respect in both seasons.

Moreover, the interaction between the two tested factors indicated that combination of 50 ppm NAA treatment applied in the second date recorded the highest values of TSS 22.00 and 18.45 % against 16.90 and 16.00 % for control treatment in the first date in the first and the second seasons, respectively. Other combinations gave an intermediate values in this respect.

Table 10. Effect of GA₃, citric acid, NAA and application date on T.S.S. of Keitt mango trees (2013 and 2014 seasons).

Treatments	T.S.S. (%)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	16.90 h	17.00 h	16.95 F	16.00 l	16.01 l	16.01 G
GA ₃ at 20 ppm	17.50 g	18.00 f	17.75 E	16.52 k	16.85 j	16.68 F
GA ₃ at 40 ppm	18.00 f	18.50 e	18.25 D	16.94 i	17.06 h	17.00 E
Citric acid at 400 ppm	18.50 e	19.00 d	18.75 C	17.26 g	17.79 f	17.52 D
Citric acid at 800 ppm	19.00 d	20.00 c	19.50 B	17.89 e	18.09 d	17.99 C
NAA at 25 ppm	19.00 d	20.00 c	19.50 B	18.10 d	18.28 c	18.19 B
NAA at 50 ppm	21.00 b	22.00 a	21.50 A	18.36 b	18.45 a	18.40 A
Mean	18.56 B	19.21 A		17.29 B	17.50 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

3.3.2.2. Acidity (%)

Table, 11 illustrates that all tested treatments exerted high reductive effect on fruit acidity (%) as compared with control in both seasons. However, 50 ppm NAA treatment in first season and 25 and 50 ppm NAA treatments in second season gave a similar and high positive effect than other tested treatments in this concern.

Moreover, application date showed no significant effect on fruit acidity (%) in 2013 season. However, the first date exerted pronounced reductive effect on fruit acidity (%) than the second date in 2014 season.

Furthermore, the interaction between the two tested factors indicated that combinations of 50 ppm NAA treatment applied in the second date in 2013 season and 25 and 50 ppm NAA treatments applied in the second date in 2014 season gave similar and higher reductive effect on fruit acidity (%) as compared with the control treatment. Other combinations exerted an intermediate values in this respect in both seasons.

3.3.2.3. Fruit total sugars content

Table, 12 illustrates that all GA₃, citric acid and NAA treatments exerted higher positive effect on total sugars as compared with control treatment in both seasons. Briefly, 50 ppm NAA treatment increased fruit total sugars and recorded 16.85 and 12.94 % against 13.99 and 11.54 % for control treatment in 2013 and 2014 seasons, respectively.

Furthermore, the second application date enhanced fruit total sugars (%) and scored 15.75 and 12.58 % against 15.56 and 12.22 % for other ones in 2013 and 2014 seasons, respectively.

Moreover, the interaction between the two tested factors showed that combination of 50 ppm NAA treatment applied in the second date increased fruit total sugars (%) and scored 17.00 and 13.16 % against 13.99 and 11.54 % for control treatment in the first date in 2013 and 2014 seasons, respectively. Other combinations gave an intermediate values in this sphere.

Table 11. Effect of GA₃, citric acid, NAA and application date on acidity of Keitt mango trees (2013 and 2014 seasons).

Treatments	Acidity (%)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	0.33 a	0.32 a	0.33 A	0.30 a	0.30 a	0.30 A
GA ₃ at 20 ppm	0.31 b	0.30 b	0.30 B	0.29 ab	0.26 cd	0.27 B
GA ₃ at 40 ppm	0.30 b	0.28 c	0.29 B	0.28 bc	0.26 d	0.27 B
Citric acid at 400 ppm	0.27 cd	0.26 d	0.26 C	0.25 de	0.24 ef	0.24 C
Citric acid at 800 ppm	0.26 d	0.25 de	0.26 C	0.24 ef	0.23 fg	0.23 C
NAA at 25 ppm	0.25 de	0.25 de	0.25 CD	0.22 g	0.20 h	0.21 D
NAA at 50 ppm	0.23 ef	0.23 f	0.23 D	0.20 h	0.19 h	0.19 D
Mean	0.27 A	0.27 A		0.25 A	0.24 B	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

Table 12. Effect of GA₃, citric acid, NAA and application date on fruit total sugar content of Keitt mango trees (2013 and 2014 seasons).

Treatments	Total sugar (%)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	13.99 j	14.00 j	14.00 F	11.54 m	11.56 m	11.55 G
GA ₃ at 20 ppm	15.00 i	15.23 h	15.11 E	11.89 l	11.98 k	11.93 F
GA ₃ at 40 ppm	15.24 h	15.54 g	15.39 D	12.12 j	12.45 g	12.28 E
Citric acid at 400 ppm	15.86 f	15.92 f	15.89 C	12.29 i	12.88 d	12.58 D
Citric acid at 800 ppm	16.00 ef	16.22 cd	16.11 B	12.40 h	12.96 c	12.68 C
NAA at 25 ppm	16.12 de	16.34 c	16.23 B	12.56 f	13.09 b	12.82 B
NAA at 50 ppm	16.70 b	17.00 a	16.85 A	12.72 e	13.16 a	12.94 A
Mean	15.56 B	15.75 A		12.22 B	12.58 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

3.3.2.4. Ascorbic acid (mg/100 ml juice)

Table, 13 reveals that all tested treatments increased fruit ascorbic acid content as compared with control treatment in both seasons. Generally, 50 ppm NAA treatment proved to be the superior treatment and scored 37.16 and 36.68 mg ascorbic acid /100 ml juice against 33.99 and 33.61 mg ascorbic acid /100 ml juice for control treatment in 2013 and 2014 seasons, respectively.

Furthermore, the second application date surpassed the analogous one in this respect in both seasons.

Moreover, the combination of 50 ppm NAA treatment applied in the second date scored 37.33 and 37.21 mg ascorbic acid /100 ml juice against 33.98 and 33.60 mg ascorbic acid /100 ml juice for control treatment in the first and the second seasons, respectively. Other combinations gave an intermediate values in this concern.

Table 13. Effect of GA₃, citric acid, NAA and application date on ascorbic acid of Keitt mango trees (2013 and 2014 seasons).

Treatments	Ascorbic acid (mg/100 ml juice)					
	2013			2014		
	Application date					
	1 st date	2 nd date	Mean	1 st date	2 nd date	Mean
Control "tap water"	33.98 j	34.00 j	33.99 G	33.60 m	33.61 m	33.61 G
GA ₃ at 20 ppm	35.00 i	35.65 g	35.32 F	34.10 l	35.42 i	34.76 F
GA ₃ at 40 ppm	35.34 h	35.89 f	35.61 E	34.75 k	35.82 g	35.28 E
Citric acid at 400 ppm	36.00 e	36.58 d	36.29 D	35.20 j	36.00 e	35.60 D
Citric acid at 800 ppm	36.65 d	36.89 c	36.77 C	35.60 h	36.43 c	36.01 C
NAA at 25 ppm	36.84 c	37.00 b	36.92 B	35.88 f	36.92 b	36.40 B
NAA at 50 ppm	37.00 b	37.33 a	37.16 A	36.16 d	37.21 a	36.68 A
Mean	35.83 B	36.19 A		35.04 B	35.91 A	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

* 1st date: at full bloom and one month later

* 2nd date: at full bloom and two months later

The obtained results regarding the effect of NAA on fruit quality go in line with the findings of Chattha et al. (1999) ; Hairdy et al. (1997) ; Shinde et al. (2008) ; Vejendla et al. (2008) and Nkansah et al. (2012) on mangoes. They mentioned that foliar application of NAA were effective in improving the fruit characters on mango.

The obtained results of citric acid regarding their positive effect on fruit quality are in agreement with the findings of Ahmed and Abdelaal (2007) on Anna apple, Mansour et al. (2008) on Le- Conte pear and Mansour et al. (2010) on four mango cultivars. They indicated that citric acid treatment improved fruit quality of the aforementioned fruit species.

The obtained results of GA₃ regarding its enhancing effect on fruit quality are in harmony with the findings of Muarya and Singh (1981) ; Sasaki and Utsunomiya (2002) and Anila and Radha (2003) on mango trees. They showed that GA₃ treatment enhanced fruit quality of mango trees. Moreover, Sarkar and Ghosh (2005) mentioned that the spray application with GA₃ increased fruit quality of mango fruits.

IV. Conclusion

Conclusively, NAA at 50 ppm treatment applied at full bloom and two months later (the second date) induced the highest positive effect on the studied fruiting and fruit quality traits of Keitt mango trees. Citric acid exerted an intermediate affects in this concern especially 800 ppm citric acid treatment applied in the second date.

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