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Synergistic Effects of Spraying some Growth Regulators and Antioxidants on Growth and Fruiting of Tommy Atkins Mango Trees Growing in Sandy Soil

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Abstract

In order to study the effect of spraying two growth regulators (Gibberellic acid "GA_3" and Jasmonic acid "JA" each one at two concentration 15 ppm & 30 ppm) or/and two antioxidants (folic and citric acids each one at 500 ppm) on vegetative growth, fruit set and yield as well as fruit quality characteristics of mango trees *cv.* Tommy Atkins, grown in sandy soil. A field experiment was conducted during successive seasons of 2019 and 2020 at a private orchard located at Al-Wakf district, Qena Governorate. The obtained results confirmed that spraying Tommy Atkins mango trees with GA_3 and JA each one at 15 or 30 ppm as well as folic and citric acids each one at 500 ppm significantly enhanced trees vegetative growth.

Fruit set%, fruit retention%, yield (kg)/tree and its component as well as fruit quality properties (i.e. TSS%, total sugars %, vitamin C contents, total fiber% and total acidity %) were significantly improved compared to untreated trees. However the best vegetative growth traits i.e. shoot length, number of leaves/shoot and leaf area, leaves pigments, fruit set %, fruit retention % and yield weight (kg/tree) were obtained from the trees received GA_3 at 30 ppm combined with citric acid at 500 ppm, followed by those received JA at 30 ppm combined with citric acid at 500 ppm. While, spraying Tommy Atkins mango trees with JA at 30 ppm and citric acid at 500 ppm showed more effectiveness on fruit quality, followed by GA_3 combined with citric acid at 500 ppm.

***Keywords*:** *Tommy Atkins; yield; fruit quality; growth regulators, antioxidants.*

Introduction

Mango tree (*Mangifera indica* L.) One of the most important specie of the family Anacardiaceae, Genus Mangifera occupies the fifth position between fruit crops in the world (FAO, 2019). It considered as one of the most important commercial and favorable fruits in Egypt. The total fruiting area of mangos in Egypt reached 265509 feddans produced 1091535 tons. Qena Governorate where the investigation took place, mango ranks the fifth position after Ismailia, Noubaria, Sharkia and Aswan since fruiting area in this region reached 9168 feddans produced 39203 tons. (M.A.L.R., 2019).

Tommy Atkins mangoes cv. considered as one of the most important exported cultivar due to its strong shelf life (De la Cruz and Garcia, 2002). Low productivity of Tommy Atkins mango trees grown in sandy soil conditions is due to various factors i.e. environmental, cultural and hormonal factors (Sahoo *et al*., 2014).

Therefore, it was urgent require to find other co-effective solution able to increase yield with best fruit quality without increasing environmental pollution.

Gibberellins one of the most important plant hormones, which has many functions through the entire life cycle of the plant, i.e. the promotion of cell division and elongation, stem and hypocotyl elongation, root growth, and flowering induction (Thakur, 2016). Also, Jasmonic acid (JA) is a plant hormone which usually biosynthesis normally from linolenic acid by the octa-decanoid pathway and found in several fruit crops, such as *Mangifera Indica*. It was first isolated by (Demol, And Mercier,1962). The function of JA is plant growth regulator and its development processes as well as help plant to overcome a biotic and biotic stresses (Farmer *et al.,* 1992 and Avanci *et al*., 2010).

Moreover, folic acid is a form of water-soluble vitamin B that important for DNA synthesis and cell division. Most of fruits are naturally higher in folic acid. Furthermore, folic acid is required for purine and pyrimidine synthesis, amino acid inter-conversions, methylation reactions and the generation (Miller, 2013 and Georgidou *et al.,* 2016). Citric acid is a natural antioxidant compound has as auxinic action. It plays an important role in plant defense against oxidative stress induced by unfavorable conditions. Application of them is accompanied with enhancing cell division and promotion of lipase, synergistic effects on growth, flowering, quantitative and qualitative yield of fruit trees (Elade, 1992; Singh *et al*., 2001; Ahmed *et al.,* 2003 and Abo El-Komsan *et al.,* 2003).

Meanwhile, GA_3 and Jasmonic acid were found to enhance characters of growth flowering, yield and fruit quality of different fruit trees. In addition, antioxidants i.e. folic and citric acids are known to overcome or counteract the harmful effects of biotic and abiotic stresses on fruit trees growth and development.

So, the research was initiated to study the effects of GA_3, JA, Folic acid and citric acid on enhancing vegetative growth, productivity and fruit quality of Tommy Atkins mango trees grown in new reclaimed soil under salinity stress.

Materials and Methods

The current investigation has been done through the two successive seasons 2019 and 2020 on 45 uniforms in vigor, healthy, free from insects and diseases damages 13-years old Tommy Atkins mango trees. The selected trees grown in private orchard located at Al-Wakf district, Qena Governorate, where the soil texture is sandy-loamy and well drained. The chosen trees were planted at 3 X 4 meters apart. Drip irrigation system was adopted, using water supply from underground well that EC of 2.8 mmhos/cm/25°C. The trees were subjected to common horticultural practices that were annually applied in the orchard including hoeing, fertilization and pest management.

Analysis of soil

A soil composite sample was collected and subjected to physical and chemical analysis according to Wilde *et al.,* (1985) the data are shown in Table (1).

Table 1. Physical & chemical analysis of the experiment soil

Character	Values
Sand %	68.1
Silt %	24.9
Clay %	9.0
Texture grade	Sandy-loom
pH (1: 2.5 extract)	7.58
EC (1: 2.5 extract ppm) mmhos/ cm^{o}C	2.2
$CaCO_3$ %	7.98
O.M. %	0.66
N (mg/kg)	198
Phosphorus (ppm)	7.71
Available K (meq/100g)	0.73
Available Mg (meq/100g)	3.04
Available Ca (meq/100g)	27.8

Experimental work

This study included fifteen treatments from two factors; factor A included the two growth regulators and factor B which included the two antioxidants as well as their interactions. Factor (A) comprised from the two growth regulators GA_3 or JA at concentrations of 0.0, 15 and 30 ppm. Factor (B) contained two concentrations of antioxidants, folic and citric acids at 0.0 and 500ppm well as their interactions. Each treatment includes three replications, one tree per each. All examined compounds were sprayed three times yearly; first one at the end of January, the second at the end of March and the third at one month later. This experiment was arranged in split plot completely randomized block design.

During the two seasons the following parameter were determined to study the effects of different treatments on growth and fruiting.

-At the last week of June, in both seasons, the following vegetative characteristics were measured spring shoot lengths (cm) and numbers of leaves per spring shoot. Also, leaf area (cm^2) was measured by using an area meter (Area Meter Cl, 202).

-Sample of twelve mature leaves were collected from spring growth cycle from the four sides of tree to determination of chlorophylls (a and b) then total chlorophyll and carotenoids calorimetrically at the wave length of 662, 644 and 440 nm respectively, as (mg/100 g F.W). Concentration of each pigment was calculated according to Hiscox and Isralstam (1979).

Fruit setting estimated by socked eight inflorescences per each tree (two inflorescences in each main geographic direction) in perforated white paper bags after one week of full bloom. After set completed, the bags were removed for counting. Fruit set % was estimated according the following equation:

$$\text{Fruit set \%} = \frac{attached\ fruits}{total\ Number\ of\ flowers} X\ 100$$

Then, percentage of retained fruits at harvest time was calculated. 12 fruits were randomly collected, in order of 3 fruit per each said of tree, then the weight of each fruit was recorded in grams, so the main fruit weight (grams) was calculated. The yield (kg)/tree were calculated mathematically, as a result of multiplying the average fruit weight by the number of fruits/tree.

At harvest in the first week of July, number of fruits/tree was counted and 12 fruits were randomly collected, in order of 3 fruit per each said of tree, and then the weight of each fruit was recorded in grams, so the main fruit weight (grams) was calculated. Hence the yield (kg)/tree were calculated mathematically.

In addition, fruit juice chemical characteristics, i.e. percentage of total soluble solids (TSS%) by using a handy refractometer was determined.

Percentage of reducing and total sugars % as well as percentage of total acidity was determined by titration with NaOH 0.1N, Vitamin C was determined by volumetric titration method using 2,6-Dichlorophynol Endophynol Pigment and total fibers % according to A.O.A.C. (2000).

The obtained data were statistically and the differences between the means were compared by using L.S.D. values at 5% level of the probability according to (Gomez & Gomez, 1984 and Snedecor & Cochran 1990).

Results

1: Vegetative growth:

Data presented in Tables (2 & 3) showed the effect of growth regulators or antioxidants spraying and interaction of them in vegetative growth, leaf total chlorophylls and carotenoids. It is obvious that the results gave a similar trend during the two studied seasons.

Shoot lengths, numbers of leaves per shoot and leaf area as well as total chlorophylls and carotenoids of leaves of Tommy Atkins mango trees were significantly increased due to spraying the growth regulators (GA_3 or JA) or/and antioxidants (folic or citric acid). Such increment due to use any growth regulators was gradual parallel to gradual increase in each growth regulator concentration. Significant differences in these studied vegetative growth traits were existed between such two growth regulators. Growth regulators or/and antioxidants concentrations were able to cause a significant increment in shoot length, leaf area and total chlorophylls of Tommy Atkins mango trees during the two experimental seasons.

On the other side, spraying the two antioxidants (folic and citric acid) each one at 500 ppm failed to increase the number of leaves/shoot during the first seasons. Whereas, spraying GA_3 or JA at 15 ppm or 30 ppm was capable to increase the number of leaves per shoot in both experimental seasons.

In addition, data in Tables (2 & 3) indicated that all studied vegetative traits significantly responded to the interaction between growth regulators (GA_3 and JA) and antioxidants (folic and citric acid). The highest and significant values were recorded in the trees received the higher concentration from GA_3 (30 ppm) companied with citric acid at 500 ppm present shoot length (64.8 & 69.2 cm), number of leaves/shoot (17.5 & 20.4 leaf/shoot), leaf area (87.9 & 99.3 cm^2) as well as total chlorophylls (16.8 & 18.7 mg/100 g) and total carotenoids (3.1 & 3.7 mg/100 g) during the two experimental seasons respectively. On the other hand, untreated trees gave the lowest values of all vegetative growth characters (37.7 & 35.3 cm, 13.2 & 12.7l eaves/shoot, 68.7 & 67.3 cm^2, 10.9 & 10.8 mg/100 g) and (1.7 & 1.8 mg/100 g F.W)), during the two experimental seasons respectively.

In general view, it could be noticed that the combination effects has more than single growth regulators or antioxidants effects in these studied traits. Therefore, it could be concluded that spraying GA_3 at 30 ppm combined citric acid at 500 ppm would achieve a beneficial increasing the vegetative growth of Tommy Atkins mango trees.

Table 2. Vegetative growth parameters of Tommy Atkins mango cultivar as effected by spraying GA_3, JA, folic acid and citric acid, during 2019 and 2020 seasons.

Length of shoot(cm)								
Treatments	2019				2020			
	0.0 ppm Antioxidant	Folic acid 500 ppm	Citric acid 500 ppm	Mean A	0.0 ppm Antioxidant	Folic acid 500 ppm	Citric acid 500 ppm	Mean A
0.0 ppmGR	37.7	42.1	41.9	**40.6**	35.3	44.2	47.2	**42.2**
GA_3 15 ppm	48.3	53.2	55.2	**52.2**	47.7	56.4	58.9	**54.3**
GA_3 30 ppm	61.7	63.3	64.8	**63.2**	63.6	68.1	69.2	**66.9**
JA15 ppm	38.9	44.6	52.6	**45.4**	41.2	48.9	55.1	**48.4**
JA 30 ppm	53.1	55.2	59.3	**55.9**	55.7	55.8	60.2	**57.3**
Mean B	**47.8**	**51.7**	**54.8**		**48.7**	**54.7**	**58.1**	
LSD $_{5\%}$	A = 3.1 ; B = 3.5 ; AB =7.7				A= 4.3 ; B= 4.4 ; AB= 9.6			
Number of leaves/shoot								
	2019				2020			
0.0 ppm GR	13.2	13.8	13.4	**13.5**	12.7	14.3	16.5	**14.5**
GA_3 15 ppm	13.7	12.7	12.9	**13.1**	15.9	17.4	19.3	**17.5**
$GA_3$30 ppm	13.9	13.9	17.5	**15.1**	17.3	19.5	20.4	**19.0**
JA15 ppm	13.6	13.1	13.3	**13.3**	14.7	16.8	18.3	**16.6**
JA 30 ppm	13.9	13.2	13.7	**13.6**	15.9	17.7	19.1	**17.6**
Mean B	13.7	13.5	14.0		15.3	17.3	18.7	
LSD 5%	A= 1.5 ; B= NS ; AB= 2.4				A= 2.0 ; B= 1.4 ; AB= 2.9			
Area of leaf (cm^2)								
	2019				2020			
0.0 ppm GR	68.7	70.3	72.2	**70.4**	67.3	73.3	74.9	**71.8**
$GA_3$15 ppm	71.3	77.9	79.4	**76.2**	77.9	82.4	84.4	**81.6**
$GA_3$30 ppm	79.9	84.3	87.9	**84.0**	84.5	91.7	99.3	**91.8**
JA15 ppm	70.1	73.9	76.8	**73.6**	74.2	75.2	77.1	**75.5**
JA 30 ppm	71.2	75.2	77.5	**74.6**	75.5	78.1	79.4	**77.7**
Mean B	**72.4**	**76.4**	**78.76**		**75.9**	**80.1**	**83.0**	
LSD 5%	A= 4.2 ; B= 2.7 ; AB= 5.9				A= 4.5 ; B= 3.9 ; AB= 8.5			

Table 3. Leaf total chlorophylls and total carotenoids (mg/100g F.W.) of Tommy Atkins mango cultivar as affected by spraying GA_3, JA, folic acid and citric acid, during 2019 and 2020 seasons.

Total chlorophylls content (mg/100g F.W.)								
Treatments	2019				2020			
	0.0 Ppm antioxidant	Folic acid 500 ppm	Citric acid 500 ppm	Mean A	0.0 ppm Antioxidant	Folic acid 500 ppm	Citric acid 500 ppm	Mean A
0.0 ppm	10.9	11.8	12.2	**11.6**	10.8	12.1	14.3	**12.4**
GA_3 15 ppm	11.8	13.7	14.5	**13.3**	13.3	16.2	16.9	**15.5**
GA_3 30 ppm	12.3	15.5	16.8	**14.8**	16.9	17.1	18.7	**17.6**
JA 15 ppm	11.9	12.7	13.1	**12.6**	12.9	14.2	14.7	**13.9**
JA 30 ppm	12.3	13.9	14.2	**13.5**	14.2	14.6	15.3	**14.7**
Mean B	**11.8**	**13.5**	**14.2**		**13.6**	**14.9**	**15.9**	
LSD $_{5\%}$	A= 1.5 ; B=1.1 ; AB=2.2				A=1.2 ; B= 1.3 ; AB=2.7			
Total carotenoids content (mg/100g F.W.)								
	2019				2020			
0.0 ppm	1.7	2.1	2.2	**2.0**	1.8	2.2	2.4	**2.1**
GA_3 15 ppm	2.2	2.7	2.8	**2.6**	2.4	2.9	3.3	**2.9**
GA_3 30 ppm	2.9	2.9	3.1	**2.9**	3.0	3.1	3.7	**3.3**
JA 15 ppm	2.2	2.3	2.6	**2.4**	2.5	2.5	2.8	**2.6**
JA 30 ppm	2.6	2.7	2.9	**2.7**	2.7	2.7	3.1	**2.8**
Mean B	**2.3**	**2.5**	**2.7**		**2.5**	**2.7**	**3.1**	
LSD $_{5\%}$	A= 0.4 ; B=0.4 ; AB=0.9				A=0.5 ; B=0.5 ; AB= 1.1			

2- Yield and its components:

Obtained data in Tables (4 & 5) show that fruit sett % and fruit retention % as well as number of fruits, fruit weight and yield/tree were significantly increased due to spraying with GA_3, JA, Folic acid and citric acid rather than untreated trees. Moreover, significant differences were existed between each two growth regulators concentrations. Furthermore, JA treatments showed a relative superiority than those of GA_3 on fruit set and fruit retention, while spraying GA_3 the more effective in fruit weight and yield/tree compared to using.

Regarding the effect of spraying the two antioxidants on fruit setting % and fruit retention % as well as fruit number, fruit weight and yield/tree showed that the trees received citric acid at 500 ppm showed superiority than those received of folic acid at 500 ppm, the data were true during the two seasons

The interaction between the two studied factors, growth regulators and antioxidants, was significant effects. The combined treatment JA + citric acid show superiority over this of GA_3 + citric acid combination on fruit set and fruit retention. Hence, the highest fruit set % (10.4% & 11.9%) and fruit retention % (2.74% & 2.99%) were obtained from the trees that received JA at 30 ppm in combination with citric acid at 500 ppm. Contrary, untreated trees present the lowest fruit set (8.2% & 8.1%) and fruit retention (1.81% & 1.73%), during 2019 and 2020 seasons respectively.

Table 4. Fruit sett % and fruit retention % of Tommy Atkinsmango cultivar as affected by spraying GA3, JA, folic acid and citric acid, during 2019 and 2020.

Fruit set (%)								
Treatments	2019				2020			
	0.0 ppm antioxidant	Folic acid 500 ppm	Citric acid 500 ppm	Mean A	0.0 ppm Antioxidant	Folic acid 500 ppm	Citric acid 500 ppm	Mean A
0.0 ppm	8.2	8.9	9.1	**8.7**	8.1	9.1	9.4	**8.9**
GA_3 15 ppm	8.8	9.2	9.6	**9.2**	9.3	9.8	10.8	**10.0**
$GA_3$30 ppm	9.2	9.7	9.9	**9.6**	9.9	10.4	11.4	**10.6**
JA15 ppm	9.1	10.0	10.1	**9.7**	10.1	10.2	11.4	**10.6**
JA 30 ppm	9.4	10.2	10.4	**10.0**	10.2	10.6	11.9	**10.9**
Mean B	**8.9**	**9.6**	**9.8**		**9.5**	**10.0**	**11.0**	
LSD 5%	**A= 0.7 ; B= 0.5 ; AB= 1.1**				**A=0.8 ; B= 0.5 ; AB= 1.1**			
Fruit retention (%)								
	2019				**2020**			
0.0 ppm	1.81	1.99	2.10	**1.97**	1.73	2.09	2.26	**2.03**
$GA_3$15 ppm	1.89	2.08	2.43	**2.03**	2.13	2.28	2.67	**2.36**
$GA_3$30 ppm	2.07	2.21	2.68	**2.29**	2.21	2.44	2.88	**2.51**
JA 15 ppm	2.10	2.28	2.49	**2.35**	2.29	2.33	2.59	**2.40**
JA 30 ppm	2.29	2.39	2.74	**2.47**	2.45	2.51	2.99	**2.65**
Mean B	**2.03**	**2.21**	**2.49**		**2.16**	**2.33**	**2.68**	
LSD 5%	**a= 0.19 ; b= 0.15 ; ab= 0.33**				**a= 0.19 ; b= 0.22 ; ab= 0.48**			

Whereas, combined GA_3 plus citric acid was more effective on fruit number, fruit weight and yield/tree compared to JA plus citric acid combination. Hence, the tree received GA_3 at 30 ppm + citric acid at 500 ppm gave the highest fruit numbers/tree (73.9 & 66.5 fruit/tree), fruit weight (515 & 585g) and yield (38.1 & 38.9 kg/tree). On the other side, untreated trees recorded the lowest number of fruits/tree (58.3 & 57.3 fruit/tree), fruit weight (400&419 g) and yield (23.3 & 24.1 kg/tree). Hence, the increment percentage of yield/tree attained (63.52 & 61.41%) due to use GA_3 at 30 ppm plus citric acid at 500 ppm compared to untreated one during the two studied seasons, respectively.

Therefore, it is clear that spraying GA_3 plus citric on mango trees has beneficial effects in increasing the yield.

Table 5. Number of fruits/tree, fruit weight (g) and yield (kg)/tree of Tommy Atkins mango cultivar as affected by spraying GA3, JA, folic acid and citric acid, during 2019 and 2020.

Fruit number/tree								
Treatments	2019				2020			
	0.0 ppm Antioxidants	Folic acid 500 ppm	Citric acid 500 ppm	Mean A	0.0 ppm Antioxidant	Folic acid 500 ppm	Citric acid 500 ppm	Mean A
0.0ppmGR	58.3	63.3	63.7	**61.8**	57.3	62.8	64.5	**61.4**
GA_3 15 ppm	60.4	67.8	72.4	**66.9**	63.5	66.8	65.3	**65.2**
$GA_3$30 ppm	68.7	68.1	73.9	**70.2**	66.3	62.9	66.5	**65.2**
JA15 ppm	60.5	68.2	71.1	**66.6**	65.1	65.9	65.2	**65.4**
JA 30 ppm	64.7	69.3	72.4	**68.8**	65.6	66.9	66.4	**66.3**
Mean B	**62.5**	**67.3**	**70.7**		**63.6**	**65.1**	**65.7**	
LSD 5%	A= 5.2 ; B= 2.3 ; AB= 5.2				A= 4.3 ; B=1.5 ; AB=3.9			
Fruit weight (g)								
	2019				2020			
0.0 ppm GR	400	425	442	**422.3**	419	447	462	**442.7**
$GA_3$15 ppm	469	474	505	**482.7**	482	489	579	**516.7**
$GA_3$30 ppm	475	489	515	**493.0**	494	546	585	**541.7**
JA15 ppm	422	453	474	**449.7**	456	479	512	**482.3**
JA 30 ppm	461	469	495	**475.0**	479	487	529	**498.3**
Mean B	**445.4**	**462**	**486.2**		**466**	**489.6**	**535.4**	
LSD 5%	A= 28 ; B= 23 ; AB= 51				A=26 ; B= 35 ; AB=61			
Yield / tree (Kg)								
	2019				2020			
0.0 ppm GR	23.3	26.9	28.2	**26.1**	24.1	28.1	30.7	**27.5**
$GA_3$15 ppm	28.3	32.1	36.6	**32.3**	30.6	32.7	37.8	**33.7**
$GA_3$30 ppm	32.6	33.3	38.1	**34.6**	32.8	34.3	38.9	**35.3**
JA 15 ppm	25.5	30.9	33.7	**29.9**	29.7	31.6	33.4	**31.5**
JA 30 ppm	29.8	32.5	35.8	**32.7**	31.4	32.6	35.1	**33.0**
Mean B	**27.8**	**31.1**	**34.4**		**29.6**	**31.9**	**35.2**	
LSD 5%	A= 3.1 ; B= 2.7 ; AB= 5.9				A=3.0 ; B=2.0 ;AB= 4.4			

3- Fruit juice chemical properties:

Tables (6 and 7) indicate the positive and favorable effects of spraying growth regulators (GA_3 and JA) and antioxidants (folic and citric acids) on fruit juice chemical properties i.e. TSS%, reducing and total sugars %, Total acidity %, vitamin C (mg/100g F.W.) and total fiber % of Tommy Atkins mango fruits, during 2019 and 2020 seasons. It is clear

from these tables that, all growth regulators, antioxidants and their combinations were significantly improved all examined juice chemical properties of Tommy Atkins mango fruits.

Concerning the two tested growth regulators (GA_3 and JA), increasing the concentration used from 15 to 30 ppm caused a significant effect in all chemical properties of fruits. However, spraying JA at 30 ppm recorded higher contents of TSS%, total sugars%, reducing sugars % and vitamin C than spraying GA_3at 30 ppm.

While, non-significant differences were observed between the two examined antioxidants, in case of reducing sugars % and total sugars%. Regarding the total acidity % and total fiber % of Tommy Atkins mango fruits spraying anyone of the two antioxidants caused a significant effective in decreasing these two parameters (Table 7). However, spraying citric acid at 500 ppm was more effective than spraying folic acid at 500 ppm.

Table 6. total soluble solids %, reducing sugars % and total sugars % of Tommy Atkins mango cultivar as affected by spraying GA_3, JA, folic and citric acids, during 2019 and 2020.

Total soluble solids %								
Treatments	**2019**				**2020**			
	0.0 ppm Antioxidants	**Folic acid 500 ppm**	**Citric acid 500 ppm**	**Mean A**	**0.0 ppm Antioxidant**	**Folic acid 500 ppm**	**Citric acid 500 ppm**	**Mean A**
0.0 ppmGR.	11.4	11.8	11.6	**11.6**	11.3	12.1	12.0	**11.8**
$GA_3$15 ppm	12.5	12.8	12.7	**12.7**	12.7	12.9	13.3	**13.0**
$GA_3$30 ppm	12.4	13.2	13.1	**12.9**	13.2	13.5	13.9	**13.5**
JA 15 ppm	12.5	12.9	13.2	**12.9**	12.8	13.2	13.7	**13.2**
JA 30 ppm	12.7	13.5	13.6	**13.3**	13.2	13.9	14.1	**13.7**
Mean B	**12.3**	**12.8**	**12.8**		**12.6**	**13.1**	**13.4**	
LSD $_{5\%}$	**A= 0.5 ; B= 0.5 ; AB= 1.1**				**A= 0.8 ; B= 0.7 ; AB= 1.5**			
Reducing sugars %								
	2019				**2020**			
0.0 ppm GR	1.8	1.9	2.0	**1.9**	1.9	2.2	2.2	**2.1**
$GA_3$15 ppm	1.9	2.0	2.1	**2.0**	2.0	2.6	2.5	**2.4**
GA_3 30 ppm	2.1	2.3	2.6	**2.3**	2.3	2.5	2.9	**2.6**
JA15 ppm	2.3	2.5	2.4	**2.4**	2.7	2.9	2.5	**2.7**
JA 30 ppm	2.4	2.6	2.5	**2.5**	2.9	3.0	2.7	**2.9**
Mean B	**2.1**	**2.3**	**2.3**		**2.4**	**2.6**	**2.6**	
LSD $_{5\%}$	**A= 0.3 ; B= NS ; AB= 0.4**				**A= 0.3 ; B=NS ; AB= 0.5**			
Total sugars %								
	2019				**2020**			
0.0 ppm GR	9.2	10.5	10.7	**10.1**	9.1	10.4	10.7	**10.1**
$GA_3$15 ppm	11.2	11.6	11.2	**11.3**	11.6	11.1	11.6	**11.4**
$GA_3$30 ppm	11.1	11.2	11.4	**11.2**	12.1	11.9	11.9	**11.9**
JA 15 ppm	11.5	11.4	11.6	**11.5**	12.1	11.8	12.1	**12.0**
JA 30 ppm	11.2	11.3	11.9	**11.5**	12.2	12.4	12.5	**12.5**
Mean B	**10.8**	**11.2**	**11.4**		**11.7**	**11.5**	**11.8**	
LSD $_{5\%}$	**A= 0.5 ; B= 0.3 ; AB= 0.7**				**A= 0.6 ; B= NS ; AB= 0.8**			

The interaction between the two growth regulators and the two anti-oxidants treatments was significant in the two seasons (Tables 6 and 7). It was clear that spraying JA at 30 ppm combined with citric acid at 500 ppm gave the highest TSS% (13.6% & 14.1%), total sugars% (11.9 & 12.5%) and lowest acidity % (0.756% & 0.609%) and lowest total fiber % (0.717% in the second season). On other words, Tommy Atkins mango trees received GA_3 at 30 ppm combined with citric acid 500 ppm present the highest reducing sugars % (2.6 & 2.9 %), vitamin C contents (53 & 56 mg/100g F.W) and lowest total fiber (0.803% in the first season), during the two experimental seasons respectively. On the other side, untreated trees recorded the lowest TSS (11.4 & 11.3 %), reducing sugars (1.8 & 1.9%), total sugars (9.2 & 9.1 %) and vitamin C (41 & 42 mg/100 g F.W.) and contrary gave the highest percentage of total acidity (0.939 & 0.941 %) and total fiber (1.012 & 1.033 %). Such applications of growth regulators and antioxidants are very important for the mango production, since improving of the fruit quality induce an increase in the packable yield.

Table 7. Total acidity %, Vitamin C (mg/100g F.W.) and total fiber % of Tommy Atkins mango cultivar as affected by spraying GA_3, JA, folic acid and citric acid, during 2019 and 2020.

Treatments	2019				2020			
Total acidity %								
	0.0 ppm Antioxidant	**Folic acid 500 ppm**	**Citric acid 500 ppm**	**Mean A**	**0.0 ppm Antioxidant**	**Folic acid 500 ppm**	**Citric acid 500 ppm**	**Mean A**
0.0 ppm	0.939	0.878	0.823	**0.880**	0.941	0.869	0.729	**0.846**
GA_3 15 ppm	0.901	0.812	0.801	**0.838**	0.849	0.807	0.707	**0.788**
$GA_3$30 ppm	0.890	0.799	0.789	**0.834**	0.806	0.780	0.677	**0.754**
JA 15 ppm	0.897	0.808	0.797	**0.820**	0.855	0.789	0.717	**0.787**
JA 30 ppm	0.879	0.773	0.756	**0.803**	0.843	0.751	0.609	**0.734**
Mean B	**0.901**	**0.814**	**0.793**		**0.853**	**0.799**	**0.688**	
LSD $_{5\%}$	**A= 0.037 ; B= 0.033 ; AB= 0.073**				**A= 0.025 ; B= 0.028 ; AB= 0.062**			
Vitamin C (mg/100g F.W.)								
	2019				**2020**			
0.0 ppm	41	43	45	**43.3**	42	46	49	**45.7**
$GA_3$15 ppm	44	46	48	**46.0**	46	48	50	**48.0**
$GA_3$30 ppm	48	49	53	**50.0**	50	53	56	**53.0**
JA 15 ppm	43	46	49	**46.0**	45	48	51	**48.0**
JA 30 ppm	46	47	51	**48.3**	51	54	55	**53.7**
Mean B	**44.6**	**46.2**	**49.2**		**46.8**	**49.8**	**52.3**	
LSD $_{5\%}$	**A=3.4 ; B= 2.8 ; AB= 6.2**				**A= 2.7 ; B= 2.0 ; AB= 4.4**			
Total fiber %								
	2019				**2020**			
0.0 ppm	1.012	0.973	0.920	**0.986**	1.033	0.875	0.853	**0.920**
$GA_3$15 ppm	0.912	0.915	0.822	**0.883**	0.883	0.796	0.803	**0.827**
$GA_3$30 ppm	0.894	0.844	0.803	**0.847**	0.837	0.748	0.756	**0.780**
JA 15 ppm	0.905	0.915	0.871	**0.897**	0.856	0.854	0.797	**0.836**
JA 30 ppm	0.835	0.813	0.885	**0.884**	0.807	0.747	0.717	**0.757**
Mean B	**0.909**	**0.888**	**0.858**		**0.883**	**0.804**	**0.785**	
LSD $_{5\%}$	**A= 0.017 ; B= 0.015 ; AB= 0.032**				**A= 0.027 ; B= 0.042 ; AB=0.093**			

Discussion

In a clearly sense, all used treatments, whether growth regulators (GA_3& JA) or antioxidants (citric acid & folic acid) significantly increased the vegetative growth characteristics and consequently an increase the yield components with improving the fruit quality.

These results confirm the importance using GA_3 or jasmonic acid as well as citric acid or folic acid.

GA_3 has a many different aspects of plant growth and development through the entire life cycle of the plant, including the promotion of cell division and elongation (Lei *et al.,* 1992 and Thakur, 2016).The major function of JA is regulating plant responses to abiotic and biotic stresses as well as plant growth regulator and plant growth and development processes (Farmer *et al.,* 1992). Citric acid is an antioxidant compound has as auxinic action; it provided disease control, cell division and promotion of lipase, synergistic effect shoot system. Various physiological processes such as nutrient uptake, respiration, photosynthesis, plant pigments as well as protein and hormones biosynthesis depend on the availability of citric acid (Arrigoni and Tullio, 2002; Ahmed *et al.,* 2003 and Abo El-Komsan *et al.,* 2003). The previous lines could be explained the positive effect of these compounds on vegetative growth which noted in the present study.

The role of growth regulators and antioxidants in enhancing vegetative growth, asshown in the present work, was emphasized by Morsy and El-Bana (2000), Nkansah *et al.,* (2012), Sahoo *et al.,* (2014) and El-Gammal *et al*. (2015).

Also, as these treatments showed an increase the yield/tree by about 60% as result of synergistic effects due spray GA_3 and citric acid. Similar positive effects on yield were observed by Ibrahim *et al*. (2007) and El-Gammal *et al*. (2015).

The role of improving fruit chemical properties of Tommy Atkins mango trees fruits by spraying GA_3, JA, folic and citric acids was given by Ibrahim *et al.*(2007) and El-Gammal *et al*. (2015).

Conclusion:

Under Qena governorate in sandy soil conditions or resembling conditions, it could be recommended to spraying Tommy Atkins mango trees, grown under salt stress, by Jasmonic acid (JA) at 30 ppm + citric acid at 500 ppm or GA_3 at 30 ppm + citric acid at 500 ppm three times yearly to improve vegetative growth, yield and fruit quality.

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التأثيرات المتداخلة لرش بعض منظمات النمو ومضادات الأكسدة على النمو والمحصول وجودة الثمار فى أشجار المانجو تومي أتكنز النامية في التربة الرملية.

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الملخص

أجريت هذه التجربة لدراسة تأثير رش منظمى نمو هما حمض الجبريليك والجاسمونك كلاهما بتركيز ١٥ أو ٣٠ جزء فى المليون وكذلك رش مضادي للأكسدة هما حمض الفوليك وحمض السيتريك كلاهما بتركيز ٥٠٠ جزء فى المليون على النمو الخضرى والمحصول وجودة الثمار فى أشجار المانجو صنف التوميأتكنز النامية فى الأراضى الرملية فى بستان خاص بمركز الوقف بمحافظة قنا.

أوضحت النتائج أن رش اشجار المانجو التومي أتكنز بحمض الجبرليك أو حمض الجاسمونك بالتركيزين السابقين وكذلك حمض الفوليك أو حمض السيتريك كلاهما بتركيز ٥٠٠ جزء فى المليون أدى إلى حدوث تحسن معنوى على كل صفات النمو الخضرى. كما تحسنت نسبة عقد الثمار، وكمية المحصول، وكذلك مواصفات جودة الثمار متمثلة فى: نسبة (المواد الصلبة الذائبة والسكريات الكلية والمختزلة وفيتامين ج والحموضة الكلية وكذلك الألياف الكلية بالثمرة) وذلك مقارنة بالكنترول.

هذا وقد اعطت الأشجار التى تم رشها بحمض الجبريلك بتركيز ٣٠ جزء فى المليون مصحوباً برش حمض السيتريك بتركيز ٥٠٠ جزء فى المليون أفضل نمو خضرى متمثلاً فى طول الأفرع وعدد الأوراق على الفرع وكذلك مساحة سطح الورقة، ومحتوي الصبغات النباتية بالورقة (الكلوروفيل والكاروتينات) وأعلى نسبة عقد للثمار وكذلك اعلى نسبة للثمار الباقية على الأفرع وكمية المحصول للشجرة. بينما أعطت الأشجار التى تم رشها بحمض الجاسمونك بتركيز ٣٠ جزء فى المليون وحمض السيتريك بتركيز ٥٠٠ جزء فى المليون أفضل مواصفات لجودة الثمار تلاها فى ذلك الأشجار التى تم رشها بحمض الجبريلك بتركيز ٣٠ جزء فى المليون مصحوباً برش حمض الستريك بتركيز ٥٠٠ جزء فى المليون.