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Effect of NAA and Fulvic Acid Spray on Vegetative Growth, Productivity and Fruit Quality of "Taimour" Mango Cultivar

Mohamed, A. Hussein, Emad El-dien H. Abd El aall and Esraa M. Elsayed[1]

ABSTRACT

This investigation was conducted on 16-year-old "Taimour" mango trees grown in a private orchard located at Tema district, Sohag Governorate, aiming to study the effect of foliar applications of Fulvic acid at (1000, 2000, and 3000 ppm) and NAA at (15, 30, and 45 ppm) on growth, leaf mineral composition, fruit retention, yield, and fruit quality during the 2019, 2020, and 2021 seasons. This experiment was designed and arranged in a complete randomized block design with three replicates per treatment and one "Taimour" mango tree per each. The selected trees (30) received thrice sprays with NAA before flowering, during full bloom, and after fruit set; meanwhile, Fulvic acid was sprayed thrice (before flowering, after fruit set, and one month later). Enhancements in leaf area, chemical composition, fruit retention percentage, yield, and fruit quality materially accompany single and combined applications with the abovementioned concentrations. A significant decline in the percentages of titratable acidity was observed due to the application of the present treatments. Using Fulvic acid was more effective than NAA for enhancing leaf area and its chemical composition. Moreover, using NAA was superior than using Fulvic acid in terms of improving yield, fruit quality, and fruit retention percentage. Using a combination of both materials was preferable to using them separately. The highest values among all parameters were achieved by spraying "Taimour" mango trees with 3000 ppm Fulvic acid + 45 ppm NAA followed by 2000 ppm Fulvic acid+ 30 ppm NAA in the three experimental seasons compared with control and other treatments. It can be concluded that foliar application of 3000 ppm Fulvic acid+ 45 ppm NAA is useful in improving the vegetative growth and nutritional status of "Taimour" mango trees and produces a high yield with good fruit quality under Sohag Governorate conditions.

Keywords: NAA, Fulvic acid, fruit quality and "Taimour" mango.

INTRODUCTION

Mango (*Mangifera indica* L.), is a popular and medicinal fruit crop grown in tropical and subtropical regions (Mohamed *et al.,* 2016), known as the king of fruits. Mango is considered the most popular fruit in Egypt, ranking second in terms of acreage after citrus. Mango cultivated area reached about 294,000 Fed. (Ministry of Agriculture and Land Reclamation, 2021). Many problems affect mango productivity, such as poor fruit set and a high fruit drop percentage at different growth stages. Using some substances has an important role in increasing fruit sets and reducing fruit drops, especially during high temperatures. It also increases mango trees' resistance to environmental conditions such as frost and high temperatures.

Plant growth regulators have been reported to play a major role in fruit growth and fruit drop in mango (Ram, 1992), which counteract the enzymes responsible for creating the abscission zone and result in fruit drop reduction. Fruit drops in mango trees are likely caused by a lack of auxins and high levels of inhibitors, according to studies by Krisanapook *et al.* (*2000*) and Ram (2000). Auxins are several growth regulators exogenously applied to horticultural crops. Many researchers have reviewed the role of such growth regulators in increasing the yield and quality of mango trees. For instance, Kassem and Marzouk (2004) found that applying 30 ppm NAA and 50 ppm GA3 during the pea stage to Zebda mango trees significantly increased fruit retention and decreased fruit drop.

Naturally occurring hormones play a major role in mango fruit growth and fruit drop (Ram, 1992). An increase in auxin level corresponds with a period of rapid growth, while a high inhibitor level corresponds with a high fruit drop rate. Haidry *et al.* (1997) and Vejendla *et al.* (2008), they indicated that NAA application has a highly positive effect on reducing fruit drop. Furthermore, sprayed NAA on mango trees reduced flower drop, gave high flower retention, increased yield, and improved fruit quality. Plant growth regulators such as NAA reduced flower drop, gave high flower retention, and increased yield and fruit quality in mango and other fruit species such as apple, citrus,

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[1]Hort. Dept. Fac. of Agric. Souhag Univ., Egypt.

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and guava (Iqbal *et al*., 2009). Fulvic acid increases the photosynthetic rate and reduces the opening of stomata and the transpiration rate to regulate plant growth (Anjum *et al*., 2011and Huang *et al*., 2020). It also enhances mineral element absorption (Justi *et al*., 2019 and Wang *et al.,* 2019). Besides, it improves the transfer of minerals directly inside the plant cells, both fresh and dry weights (Chen *et al.,* 2004) and chelates mineral nutrients (Lotfi *et al*., 2015 and Malan, 2015). In addition, spraying Fulvic acid has significantly improved the average size, weight, and shape index (length and diameter) of the fruit of table grape (Ferrara and Brunetti, 2010), TSS%, and TSS/acidity ratio, while decreasing the percentage of total acidity (Zhang *et al*., 2013 and Suh *et al*., 2014). Besides, Fulvic acid significantly increased leaf surface area, fruit number per tree, fruit weight and volume, TSS% and TSS/acidity ratio, and total sugars in the fruits of apple cv. Anna (El-Boray *et al*., 2015) and apricot cv. Canino (Haggag *et al*., 2016).

The present work aims to evaluate the influence of Fulvic acid and plant growth regulators such as NAA on growth, yield and fruit quality of "Taimour" mango trees grown in silty clay soils.

MATERIALS AND METHODS

This study was conducted during three successive seasons (2019, 2020, and 2021) on thirty trees 16- years old "Taimour" mango trees budded on seedling rootstock grown in a private orchard located at Tema district, Sohag Governorate, Upper Egypt, in silty clay soil and with a water table depth of not less than two meters. The trees were planted 7×7 meters apart. And irrigated with surface irrigation system The selected trees were subjected to all the normal horticultural practices. "Taimour" mango trees under study were selected at random to carry out the treatments during the three successive seasons. The selected trees were almost uniform in their vigour growth, free from pathological and physiological disorders and all received the same horticultural management (irrigation, fertilization, pests, and disease control usually applied in the orchard except for the foliar application of NAA and Fulvic acid). The results of orchard soil analysis according to Wilde *et al.* (1985) are shown in Table (1).

The trees were sprayed with NAA and Fulvic acid treatments as follows:

T1= Control (Tree spray with water only).

T2= Tree spray with 1000 ppm Fulvic acid.

T3= Tree spray with 2000 ppm Fulvic acid.

T4= Tree spray with 3000 ppm Fulvic acid.

T5= Tree spray with 15 ppm NAA.

T6= Tree spray with 30 ppm NAA.

T7= Tree spray with 45 ppm NAA.

T8= Tree spray with 1000 ppm Fulvic acid and 15 ppm NAA.

T9= Tree spray with 2000 ppm Fulvic acid and 30 ppm NAA.

T10= Tree spray with 3000 ppm Fulvic acid and 45 ppm NAA.

The trees were sprayed with NAA thrice before flowering, during full bloom, and after fruit set, and with Fulvic acid thrice spray before flowering, after fruit set, and one month after fruit set. Triton B was added to all treatments at 0.1% as a wetting agent.

Table 1. Mechanical, physical, and chemical analysis of the tested orchard soil

Particle size distribution:

Soil properties	
Sand %	9.4
Silt %	54.6
Clay	36.0
Texture	Silty clay
pH(1:2.5 extract)	7.30
EC (1: 2.5 extract) (mmhos/Icm/25^{o}C)	0.55
O.M. %	2.28
$CaCO_3$ %	1.59
Total N %	0.19
Available P (ppm, Olsen)	5.0
Available K (ppm/ ammonium acetate)	533
Available Mg (ppm)	122.00
Available S (ppm)	6.77
B (ppm) (hot water extractable)	0.30
Available EDTA extractable micronutrients (ppm)	
Zn	1.15
Fe	12.22
Mn	10.32
Cu	1.40

Experimental Design:

The experiment followed a complete randomized block design on 30 trees, as ten treatments were applied with three replicates per treatment; each tree was considered a replicate.

Leaf area and its chemical composition

Twenty leaves below panicles of the spring growth cycle according to Summer (1985) were taken (2nd week of July) for measuring leaf area according to Ahmed and Morsy (1999), as well as chlorophylls A and B, then the summation of both for producing total chlorophylls (mg/100 g F.W.) according to Von-Wettstein (1957), and percentages of N, P, and K in the dried leaves were determined according to Wilde *et al.* (1985).

Fruit retention

The percentage of fruit retention was estimated by dividing the number of fruits retained on each tree just before harvesting by the total number of initial fruits set and multiplying the product by 100.

Number of fruits/tree: Counted the number of fruits in each tree at harvest. Yield per tree: Harvesting was achieved in the last week of July in both seasons when the flesh of fruits became light yellowish and the yield expressed in weight (kg) was recorded.

Fruit quality: Twenty fruits were taken from each tree to measure fruit weight (g), fruit length (cm), fruit width (cm), the percentage of pulp, T.S.S.%, total acidity % (as citric acid/100 ml juice), the percentage of total sugars, the percentage of reducing sugars and vitamin C content (as mg/100 ml juice) as outlined by A.O.A.C. **(**1995**).**

Statistical Analysis:

All the obtained data were tabulated and statistically analyzed according to Mead *et al.* (1993) and averages of treatments were compared by using the new L.S.D. test at 5% according to Steel and Torrie (1984).

RESULTS

The leaf N, P, and K content

The results presented in Table (2) clearly that spraying Fulvic acid and NAA, either alone or in combination, increases N, P, and K levels in “Taimour” mango tree leaves compared to the untreated check treatment. Fulvic acid was more effective than NAA in significantly increasing the levels of these nutrients in leaves when sprayed alone during all three seasons studied. When used in combination, the levels were further improved. The highest values were observed in trees sprayed with a combination of 3000 ppm Fulvic acid and 45 ppm NAA, followed by trees sprayed with 2000 ppm Fulvic acid and 30 ppm NAA. On the other hand, the lowest values were observed in untreated trees. These results were true during the three seasons.

The leaf area and Total chlorophylls

The results in Table (2) demonstrate that foliar application of NAA and Fulvic acid significantly increased leaf area and Total chlorophyll in "Taimour" mango trees compared to untreated trees. Fulvic acid was more effective than NAA when applied alone to enhance leaf area and Total chlorophyll in "Taimour" mango trees during the 2019, 2020, and 2021 seasons. Additionally, the combination of Fulvic acid and NAA further improved these parameters compared to using each material alone. The highest values were recorded for trees sprayed with 3000 ppm Fulvic acid and 45 ppm NAA, followed by trees sprayed with 2000 ppm Fulvic acid and 30 ppm NAA. On the other hand, the lowest values were observed in untreated trees. Similar trend was observed during the three experimental seasons.

Fruit retention

The data presented in Table (3) shows that the fruit retention percentage was lowest in the control trees during all three seasons studied (0.58, 0.57, and 0.60). However, foliar application of Fulvic acid positively impacted fruit retention compared to control trees. Additionally, NAA treatments were more effective in increasing fruit retention percentages in all seasons than Fulvic acid treatments. The highest number of fruit retentions at the mature stage was observed in trees treated with a spray containing 3000 ppm Fulvic acid and 45 ppm NAA in all three seasons (1.06, 1.07, and 1.10), followed by 2000 ppm Fulvic acid and 30 ppm NAA (0.99, 1.02, and 1.06). On the other hand, the lowest values were observed in untreated trees. Similar trend was noticed during three seasons.

Number of fruits/ trees and Yield as (Kg)/ tree:

The results in Table (3) indicate that using NAA and Fulvic acid treatments, either alone or in combination, led to a significant increase in the number of fruits produced per tree compared to the control treatment. The untreated trees produced the least number of fruits (172.00, 209.00, and 185.00) in the three seasons studied. The maximum values of fruit number per tree were observed on the trees were sprayed with 3000 ppm Fulvic acid and 45 ppm NAA, which resulted in the highest number of mango fruits per tree in all three seasons (328.67, 351.67, and 350.00) followed by the trees were sprayed with 2000 ppm and Fulvic acid 30 ppm NAA, but No significance differences appeared between the treatments (3000 ppm Fulvic acid and 45

ppm NAA) and (2000 ppm Fulvic acid and 30 ppm NAA) in second and third seasons. Moreover, in all three seasons studied (2019, 2020, and 2021), the NAA treatments increased the number of fruits per tree more significantly than Fulvic acid treatments at all concentrations. Concerning the yield (kg/tree), data in Table (3), indicated that all treatments were statistically increased tree yield (kg/tree) compared with the control treatment in the three seasons. Also, spraying trees with3000 ppm Fulvic acid and 45 ppm NAA produced the highest yield (kg) per tree (94.08, 103.65 and 108.19 kg/tree) followed by the trees spray with 3000 Fulvic acid and 30 ppm NAA (94.08, 103.65, and 108.19 kg/tree) in the three studied seasons, respectively. On the other hand, the untreated trees exhibited the lowest yield weight (37.07, 45.51, and 40.86 kg/tree) in the three studied seasons, respectively. Finally, all NAA treatments gave better values of mango yield weight (kg) per tree compared with Fulvic acid treatments at all concentrations in the three studied seasons, 2019, 2020, and 2021.

Physical and chemical characteristics of the fruits

It is noticed from the data in Tables (3& 4& 5) that foliar application of Fulvic acid and NAA alone or combined significantly improved fruit quality.

Physical properties:

Results in Tables (3 and 4) showed that foliar application of NAA and Fulvic acid alone or combined significantly increased fruit weight (g), length (cm), width (cm), and pulp weight percentage compared to the control treatment in all seasons. In this respect, the highest values for fruit physical properties parameters were recorded from trees sprayed with 3000 ppm Fulvic acid and 45 ppm NAA treatments for fruit weight (286.03, 294.67 and 309.07g), fruit length (12.77, 13.00 and 12.90cm), fruit width (7.63, 7.93 and 8.00 cm), percentage of pulp weight (75.700, 78.26 and 78.53 cm) in three studied seasons compared to other treatments. However, the untreated trees exhibited the lowest fruit weight (215.43, 217.67, and 220.77 g), fruit length (10.46, 10.63, and 10.83cm), fruit width (6.00, 6.23, and 6.26 cm) and percentage of pulp weight (69.00, 69.36 and 69.80 cm) in the three studied seasons, respectively. Furthermore, from the previous results in Tables (3 and 4), it is clear that spraying trees with NAA treatments is better than Fulvic acid treatments for increasing the fruit's physical properties. However, the tree sprayed with NAA and Fulvic acid gave better fruit physical properties than the tree sprayed with NAA or Fulvic acid alone in all three studied seasons.

- Chemical properties:

Presented data in Tables (4 and 5) showed the effect of different treatments of foliar application treatments on TSS (%), acidity (%), total sugars(%), reducing sugars (%), and Vitamin C content of "Taimour" mango fruits in 2019, 2020 and 2021seasons.

As for TSS %, data in Table (4) indicated that T10 (the trees sprayed with 3000 ppm Fulvic acid and 45 ppm NAA) was the superior treatment for increasing TSS (16.37, 16.70, and 16.80%), followed by T9 (the trees sprayed with 3000 ppm Fulvic acid and 45 ppm NAA) in 2019, 2020, and 2021 seasons, respectively. Concerning total fruit acidity, it is obvious that spraying mango trees with NAA and Fulvic acid reduced the fruit content of total acidity % in three seasons in comparison with the control treatment. In contrast, the untreated tree recorded the highest values (0.446, 0.421, and 0.419%), respectively.

Concerning the total and reducing sugars% as shown in Table (5), the obtained results indicated that untreated trees exhibited the lowest total sugars (13.27, 13.57 and 13.60%) and reducing sugars (3.72, 4.02 and 4.06%), respectively, in the three studied seasons. On the other hand, trees treated with 3000 ppm Fulvic acid and 45 ppm NAA gave higher percentages of mango total sugars (14.90, 15.60, and 15.73%) and reducing sugars (4.70, 5.16 and 5.23%), respectively.

As concerns of ascorbic acid (mg/100ml juice), data presented in the same table reveal that in three seasons, the highest values were obtained in the fruits harvested from trees sprayed with 3000 ppm Fulvic acid and 45 ppm NAA (45.93, 44.33 and 44.60 mg/100ml juice).

From the previous results in Tables (4 and 5), it is clear that the fruit's Chemical properties especially total sugars was increased and reached the maximum values by spraying trees with NAA treatments followed by Fulvic acid treatments when sprayed alone. However, the tree sprayed with NAA and Fulvic acid gives the best fruit Chemical properties than the tree sprayed with NAA or Fulvic acid alone in all three studied seasons.

Table 2. Effect of foliar sprays with NAA and Fulvic acid on the leaf area (cm^2) and the percentages of N, P and K and total chlorophylls (mg/ 100 g F.W) in the leaves of "Taimour" mango trees during 2019, 2020 and 2021 seasons.

Treatments	Leaf area (cm^2)			Leaf N %			Leaf P %			Leaf K %			Total chlorophylls (mg/ 100 g F.W)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
Control	60.00± 0.80	61.46± 0.95	62.36± 0.58	1.89± 0.02	1.85± 0.02	1.79± 0.06	0.11± 0.01	0.13± 0.002	0.13± 0.005	1.22± 0.006	1.28± 0.017	1.26± 0.026	27.46± 0.77	29.10± 0.79	30.83± 0.92
1000 ppm Fulvic acid	68.50± 0.25	69.70± 0.17	70.80± 0.10	2.15± 0.02	2.11± 0.02	2.12± 0.01	0.19± 0.01	0.22± 0.015	0.22± 0.006	1.42± 0.01	1.52± 0.005	1.49± 0.023	34.26± 0.20	35.00± 0.36	38.13± 0.30
2000 ppm Fulvic acid	69.66± 0.18	70.86± 0.40	72.00± 0.29	2.21± 0.04	2.19± 0.03	2.20± 0.02	0.20± 0.01	0.23± 0.015	0.24± 0.001	1.46± 0.011	1.54± 0.006	1.54± 0.006	36.00± 0.80	36.73± 0.61	39.50± 1.15
3000 ppm Fulvic acid	71.46± 0.44	72.53± 0.29	73.30± 0.35	2.35± 0.08	2.32± 0.09	2.24± 0.01	0.21± 0.005	0.25± 0.01	0.25± 0.006	1.49± 0.008	1.56± 0.006	1.57± 0.009	37.10± 0.40	38.07± 0.20	41.63± 0.11
15 ppm NAA	62.60± 0.61	65.50± 0.42	64.63± 0.52	1.96± 0.04	1.92± 0.02	1.92± 0.03	0.14± 0.005	0.16± 0.02	0.15± 0.01	1.30± 0.005	1.35± 0.015	1.35± 0.007	29.13± 0.97	30.30± 0.52	33.13± 1.20
30 ppm NAA	65.40± 0.45	67.60± 0.26	67.80± 0.67	2.04± 0.01	1.97± 0.01	2.01± 0.01	0.15± 0.006	0.18± 0.005	0.17± 0.006	1.33± 0.012	1.41± 0.012	1.39± 0.006	31.26± 0.76	31.87± 0.64	35.37± 0.50
45 ppm NAA	67.56± 0.20	68.83± 0.42	69.36± 0.64	2.10± 0.10	2.05± 0.03	2.08± 0.01	0.17± 0.001	0.20± 0.01	0.20± 0.002	1.37± 0.006	1.45± 0.016	1.43± 0.007	33.23± 0.92	33.70± 0.65	36.80± 0.72
1000 ppm Fulvic acid+ 15 ppm NAA	72.66± 0.37	73.60± 0.36	74.66± 0.40	2.26± 0.04	2.27± 0.18	2.32± 0.01	0.22± 0.006	0.29± 0.011	0.27± 0.007	1.53± 0.016	1.64± 0.035	1.66± 0.032	38.16± 0.98	40.97± 1.01	43.73± 1.55
2000 ppm Fulvic acid+ 30 ppm NAA	74.30± 0.35	75.63± 0.68	77.70± 1.35	2.22± 0.15	2.25± 0.09	2.36± 0.01	0.26± 0.01	0.31± 0.005	0.30± 0.01	1.62± 0.03	1.72± 0.008	1.73± 0.012	39.70± 0.30	42.60± 0.26	45.37± 0.05
3000 ppm Fulvic acid+ 45 ppm NAA	78.83± 0.50	80.70± 0.46	81.83± 0.56	2.10± 0.02	2.23± 0.05	2.54± 0.02	0.29± 0.02	0.39± 0.015	0.35± 0.016	1.78± 0.012	1.83± 0.020	1.85± 0.014	41.06± 0.80	43.17± 0.15	45.60± 0.10
New L.S.D at 0.05	1.28	1.38	1.73	0.02	0.01	0.02	0.01	0.02	0.04	0.04	0.04	0.05	1.21	0.93	1.35

Table 3. Effect of foliar sprays with NAA and Fulvic acid on Yield/ tree (kg.), fruit retention, number of fruits/ tree and fruit weight (g.) of "Taimour" mango trees during 2019, 2020 and 2021 seasons

Treatments	Yield/ tree (kg.)			Fruit retention			Number of fruits/ tree			Fruit weight (g.)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
Control	37.07± 2.28	45.51± 2.14	40.86± 2.53	0.58± 0.01	0.57± 0.014	0.60± 0.02	172.00±4. 16	209.00± 3.05	185.00± 4.51	215.4± 4.78	217.67± 5.13	220.77± 5.17
1000 ppm Fulvic acid	40.00± 0.402	52.72± 4.34	47.98± 0.338	0.62± 0.005	0.62± 0.01	0.68± 0.02	181.00± 0.56	236.0± 10.52	212.00± 1.57	221.00± 11.35	223.33± 11.93	226.3± 33.69
2000 ppm Fulvic acid	42.86± 1.631	57.71± 0.492	56.23± 5.38	0.67± 0.02	0.68± 0.009	0.73± 0.012	189.00± 3.60	250.33± 2.35	240.3± 12.71	226.77± 1.00	230.57± 1.52	233.90± 0.57
3000 ppm Fulvic acid	46.31± 1.698	59.58± 0.740	60.32± 0.300	0.7± 0.005	0.73± 0.007	0.78± 0.018	201.33± 3.76	255.67± 1.67	255.33± 0.33	230.00± 1.20	233.07± 1.50	236.27± 1.15
15 ppm NAA	51.95± 4.99	64.03± 6.09	62.11± 1.681	0.74± 0.007	0.77± 0.011	0.83± 0.17	221.33± 9.36	269.7± 10.69	257.66± 1.33	234.47± 1.00	237.17± 0.11	241.07± 0.64
30 ppm NAA	60.24± 1.101	83.75± 11.03	75.61± 3.54	0.80± 0.011	0.82± 0.018	0.88± 0.015	249.33± 2.35	338.7±27. 22	302.00± 7.21	241.53± 5.16	247.47± 6.10	250.33± 6.20
45 ppm NAA	63.89± 0.678	81.25± 1.568	82.30± 2.46	0.85± 0.012	0.89± 0.01	0.92± 0.01	256.00± 9.96	319.33± 2.19	317.33± 4.34	249.57± 0.50	254.43± 3.07	259.33± 1.52
1000 ppm Fulvic acid+ 15 ppm NAA	71.17± 6.14	88.28± 3.43	89.83± 3.67	0.93± 0.017	0.94± 0.02	0.98± 0.007	276.67± 9.96	328.33± 3.33	332.00± 2.64	257.00± 1.69	268.83± 1.91	270.50± 2.08
2000 ppm Fulvic acid+ 30 ppm NAA	83.14± 3.33	95.29± 1.590	98.00± 4.62	0.99± 0.011	1.02± 0.01	1.06± 0.015	306.33± 6.75	344.00± 2.00	338.67± 1.20	271.40± 7.19	277.00± 6.85	289.33± 7.42
3000 ppm Fulvic acid+ 45 ppm NAA	94.08± 7.00	103.65± 5.24	108.19± 2.82	1.06± 0.02	1.07± 0.01	1.10± 0.007	328.67± 8.18	351.67± 4.04	350.00±2. 89	286.03± 0.52	294.67± 2.00	309.07± 11.85
New L.S.D at 0.05	6.00	5.50	5.15	0.04	0.04	0.04	16.71	28.28	14.67	7.94	8.55	8.68

Table 4. Effect of foliar sprays with NAA and Fulvic acid on the fruit length (cm.), Fruit width (cm.), the percentage of pulp and the percentage of total soluble solids of "Taimour" mango trees during 2019, 2020 and 2021 seasons.

Treatments	Fruit length (cm.)			Fruit width (cm.)			The percentage of pulp			The percentage of total soluble solids (TSS)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
Control	10.46± 0.03	10.63± 0.08	10.83± 0.08	6.00± 0.05	6.23± 0.07	6.26± 0.09	69.00± 0.10	69.36± 0.68	69.80± 0.72	12.53± 0.12	12.10± 0.1	11.93± 0.19
1000 ppm Fulvic acid	10.93± 0.02	11.00± 0.03	11.10± 0.09	6.23± 0.08	6.47± 0.03	6.63± 0.08	69.60± 0.40	70.63± 0.55	70.97± 0.41	12.80± 0	12.67± 0.08	12.67± 0.08
2000 ppm Fulvic acid	11.03± 0.04	11.37± 0.07	11.50± 0.06	6.50± 0.07	6.73± 0.04	6.87± 0.03	70.33± 0.21	71.17± 0.28	71.83± 0.28	14.10± 0.6	14.23± 0.62	14.33± 0.62
3000 ppm Fulvic acid	11.27± 0.08	11.63± 0.02	11.77± 0.1	6.60± 0.01	6.90± 0.01	7.00± 0.1	71.43± 0.15	72.67± 0.06	73.27± 0.35	15.20± 0.07	15.40± 0.12	15.47± 0.1
15 ppm NAA	11.53± 0.03	11.77± 0.01	11.90± 0.03	6.80± 0.00	7.03± 0.03	7.13± 0.03	70.87± 0.23	71.93± 0.30	72.43± 0.20	14.93± 0.06	15.07± 0.05	15.10± 0.03
30 ppm NAA	11.60± 0.01	11.90± 0.03	12.23± 0.01	6.90± 0.02	7.17± 0.05	7.27± 0.04	72.43± 0.55	73.57± 0.25	74.00± 0.1	15.43± 0.03	15.70± 0	15.80± 0
45 ppm NAA	11.93± 0.12	12.37± 0.02	12.50± 0.1	7.07± 0.03	7.30± 0.02	7.40± 0	74.27± 0.17	75.13± 0.25	75.30± 0.35	15.73± 0.04	16.03± 0.03	16.13± 0
1000 ppm Fulvic acid+ 15 ppm NAA	12.17± 0.03	12.53± 0.01	12.60± 0.01	7.20± 0.01	7.43± 0.03	7.53± 0.02	73.40± 0.25	74.27± 0.32	74.67± 0.36	15.57± 0.07	15.83± 0.07	15.90± 0.07
2000 ppm Fulvic acid+ 30 ppm NAA	12.16± 0.11	12.35± 0.04	12.60± 0.02	7.43± 0.03	7.80± 0.01	7.83± 0.05	75.70± 0.96	76.13± 0.85	76.63± 1.09	16.07± 0.06	16.37± 0.12	16.37± 0.12
3000 ppm Fulvic acid+ 45 ppm NAA	12.77± 0.02	13.00± 0.03	12.90± 0.07	7.63± 0.09	7.93± 0.03	8.00± 0.07	75.70± 1.12	78.26± 0.64	78.53± 0.68	16.37± 0.05	16.70± 0.06	16.80± 0.06
New L.S.D at 0.05	0.18	0.21	0.14	0.13	0.28	0.12	0.86	0.78	0.86	0.01	0.01	0.01

Table 5. Effect of foliar sprays with NAA and Fulvic acid on the percentage of total sugars, reducing sugars and vitamin C contents and total acidity of "Taimour" mango trees during 2019, 2020 and 2021 seasons.

Treatments	Percentage of total sugars			Percentage of reducing sugars			Vitamin C content			Total acidity		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
Control	13.27± 0.15	13.57± 0.05	13.60± 0.10	3.72± 0.16	4.02± 0.02	4.06± 0.01	34.50± 1.04	36.33± 0.23	36.60± 0.10	0.446± 0.011	0.421± 0.001	0.419± 0.002
1000 ppm Fulvic acid	13.53± 0.05	13.90± 0.17	14.00± 0.17	4.01± 0.01	4.10± 0.05	4.12± 0.04	35.73± 0.37	37.00± 0.10	37.20± 0.20	0.428± 0.007	0.410± 0.009	0.408± 0.010
2000 ppm Fulvic acid	13.70± 0.02	14.17± 0.06	14.20± 0.00	4.11± 0.02	4.23± 0.01	4.25± 0.05	36.50± 0.40	37.73± 0.68	38.16± 0.55	0.418± 0.002	0.386± 0.005	0.384± 0.007
3000 ppm Fulvic acid	14.07± 0.07	14.40± 0.00	14.43± 0.06	4.27± 0.01	4.35± 0.02	4.38± 0.02	38.06± 0.26	40.23± 0.05	40.53± 0.20	0.396± 0.006	0.367± 0.004	0.366± 0.003
15 ppm NAA	13.90± 0.05	14.30± 0.00	14.33± 0.05	4.18± 0.03	4.28± 0.05	4.29± 0.03	37.20± 0.20	39.43± 0.49	39.76± 0.35	0.405± 0.002	0.375± 0.005	0.374± 0.005
30 ppm NAA	14.20± 0.00	14.57± 0.05	14.67± 0.15	4.31± 0.02	4.43± 0.04	4.44± 0.04	38.83± 0.37	41.03± 0.15	41.37± 0.11	0.390± 0.00	0.360± 0.001	0.358± 0.001
45 ppm NAA	14.47± 0.10	15.03± 0.10	15.10± 0.11	4.48± 0.04	4.67± 0.03	4.67± 0.02	40.33± 0.45	42.23± 0.36	42.40± 0.15	0.375± 0.006	0.348± 0.00	0.343± 0.005
1000 ppm Fulvic acid+ 15 ppm NAA	14.30± 0.06	14.80± 0.07	14.87± 0.00	4.38± 0.03	4.51± 0.0	4.53± 0.0.11	39.56± 0.49	41.50± 0.25	41.83± 0.36	0.383± 0.005	0.350± 0.006	0.348± 0.002
2000 ppm Fulvic acid+ 30 ppm NAA	14.70± 0.10	15.27± 0.04	15.30± 0.10	4.59± 0.01	4.87± 0.03	4.92± 0.07	41.17± 0.15	43.23± 0.25	43.77± 0.49	0.358± 0.008	0.328± 0.012	0.326± 0.009
3000 ppm Fulvic acid+ 45 ppm NAA	14.90± 0.05	15.60± 0.11	15.73± 0.11	4.70± 0.02	5.16± 0.15	5.23± 0.20	45.93± 6.73	44.33± 0.57	44.60± 0.60	0.336± 0.008	0.308± 0.002	0.307± 0.006
New L.S.D at 0.05	0.15	0.13	0.16	0.16	0.11	0.11	3.55	0.61	0.58	0.05	0.05	0.06

DISCUSSION

The results indicate that Fulvic acid positively impacts "Taimour" mango trees. It improves leaf area, fruit retention, yield, fruit quality, and leaf composition regarding nitrogen, phosphorous, potassium, and total chlorophyll. These findings are consistent with those of Plaza et al. (2005), who found that Fulvic acid is effective in both acidic and alkaline media. It promotes various physiological processes that depend on plant species and the developing stage, enhancing the fruit's weight and diameter, the juice's pH, and vitamin C content. According to studies by El-Khawaga (2011) and Shaheen et al. (2012), using Fulvic acid increased the total sugar percentages in grapevines. Similarly, Fulvic acid greatly increased the percentages of total sugars in grapevines (El-Khawaga, 2011; Shaheen et al., 2012). In parallel to our findings, Zancani et al., (2011) stated that fulvic acids can play a good role in the transporting of hormones inside the plants and can raise the levels of intercellular ATP and glucose-6-phosphate has a good relation with the encouragement of cell cultures. The usage of fulvic acid enhanced greatly SSC % and SSC/acidity ratio while it decreased the percentage of total acidity (Zhang et al., 2013; Abd El-Hameed et al., 2014; Suh et al., 2014). As fulvic acid can enhance antioxidants, IAA, GA3 and Cytokines hormones and vitamins, it improves the vegetative growth in plants (Abd El-Hameed et al., 2014). Besides, Priya et al., (2014) reported that fulvic acid looks like the hormone of auxin in plants, which plays a good role in the absorption of potassium and is responsible for the metabolism of starch.

The above-mentioned results show that the sprayed NAA positively affected leaf area, mineral composition, fruit retention, yield, and fruit quality. This may be due to the role of NAA in increasing auxin levels and reducing fruit drop. The obtained results agree with those concluded by Ram, 1992; Ram, 2000; Vejendla et al., 2008; Anjum et al., 2011 and Huang et al., 2020. Furthermore, NAA treatment can increase leaf area and fruit retention by multiplying and lengthening meristem cells, positively affecting fruit set and retention and reducing fruit drop. Studies conducted by Iqbal et al. (2009) and Nkansah et al. (2012) support the positive effect of NAA on fruit retention in mango trees. These results suggest that the treatment enhances the trees' nutritional status, leading to an increase in both fruit set and retention.

In conclusion, based on the results of the present study, it can be concluded that applying thrice sprays of two materials, namely 45 ppm NAA and 3000 ppm Fulvic acids together, was effective in enhancing both the quantitative and qualitative aspects of yield in "Taimour" mango trees.

REFERENCE

A.O.A.C. 1995. Official Methods of Analysis. 14th Edition, Association of Official Analytical Chemists, Washington DC. 490 – 510.

Abd El-Hameed, M.M.W., A.G. Ali, A.R. Esis and R.M. Ahmed. 2014. Reducing mineral N fertilizer partially in Thompson seedless vineyards by using fulvic acid and effective microorganisms. World Rural Observ. 6: 36-42.

Ahmed, F.F. and M.H. Morsy. 1999. A new method for measuring leaf area in different fruit species. Minia J. Agric. Res. Dev.19: 97 – 105.

Anjum, S.A., L. Wang, M. Farooq, L. Xue and S. Ali. 2011. Fulvic acid application improves the maize performance under well-watered and drought conditions. J. Agron. Crop Sci. 197: 409-417.

Chen, X., T.M. Grzegorczyk, B.I. Wu, Jr, J. Pacheco and J.A. Kong. 2004. Robust method to retrieve the constitutive effective parameters of metamaterials. Phys. Rev. E 70, 016608.

El-Boray, M.S., M.F.M. Mostafa, S.E. Salem and O.A.O. El-Sawwah. 2015. Improving yield and fruit quality of washington navel orange using foliar applications of some natural biostimulants. J. Plant Prod. 6: 1317-1332.

El-Khawaga, A.S. 2011. Partial replacement of mineral N fertilizers by using humic acid and Spirulina Platensis algae biofertilizer in Florida prince peach orchards. Middle East J. Appl. Sci.1: 5-10.

Ferrara, G. and G. Brunetti. 2010. Effects of the times of application of a soil humic acid on berry quality of table grape (*Vitis vinifera* L.) cv Italia. Span. J. Agric. Res. 8: 817-822.

Haggag, Y., Y. Abdel-Wahab, O. Ojo, M. Osman, S. El-Gizawy, M. El-Tanani, A. Faheem and P. McCarron. 2016. Preparation and in vivo evaluation of insulin-loaded biodegradable nanoparticles prepared from diblock copolymers of PLGA and PEG. Int. J. Pharm. 499: 236-246.

Haidry, G.A., B. Jala-Ud-Din, A. Ghaffoor and M. Munir. 1997. Effect of naphthalene acetic acid (NAA) on the fruit drop, yield and quality of mango (*Mangifera indica* L.) cultivar Langra. Sci. Khyber 10: 13-20.

Huang, C., Y. Wang, X. Li, L. Ren, J. Zhao, Y. Hu, L. Zhang, G. Fan, J. Xu, X. Gu and Z. Cheng. 2020. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 395: 497-506.

Iqbal, M., M.Q. Khan, K. Rehman and M. Munir. 2009. Effect of foliar application of NAA on fruit drop, yield and physico-chemical characteristics of guava (*Psidium guajava* L.) red flesh cultivar. J. Agric. Res. 47: 259-269.

Justi, M., E.G. Morais and C.A. Silva. 2019. Fulvic acid in foliar spray is more effective than humic acid via soil in improving coffee seedlings growth. Arch. Agron. Soil Sci. 65: 1969-1983.

Kassem, H.A. and H.A. Marzouk. 2004. Fruit retention, yield and postharvest fruit quality of mango in relation to: l. putrescine, GA3, NAA and urea foliar sprays. J. Adv. Agric. Res. 9: 289-298.

Krisanapook, K., L. Phavaphutanon, V. Kaewladdakorn, K. Jutamanee and A. Pichakum. 2000. Studies on fruit growth, levels of GA-like substances and CK-like substances in fruits of mango cv. Khiew Sawoey. Acta Hort. 509: 694- 704.

Lotfi, R., M. Pessarakli, P. Gharavi-Kouchebagh and H. Khoshvaghti. 2015. Physiological responses of *Brassica napus* to fulvic acid under water stress: Chlorophyll a fluorescence and antioxidant enzyme activity. Crop J. 3: 434-439.

Malan, C. 2015. Review: humic and fulvic acids. A Practical approach. In Sustainable soil management symposium. Stellenbosch, 5-6 November, Agrilibrium Publisher.

Mead, R., R.N. Gurnow and A.M. Harted. 1993. Statistical Methods in Agriculture and Experimental Biology. 2nd Ed. Chapman & Hall. London, 54-60.

Ministry of Agriculture and Land Reclamation. 2021. Economic affairs sector. Bulletin of the agricultural statistics (In Arabic), Egypt.

Mohamed, A.Y., Kh.A. Roshdy and M. A.F. Badran. 2016. Evaluation study of some imported mango cultivars grown under aswan governorate conditions. Alex. Sci. Exch. J. 37: 254- 258.

Nkansah, G.O., J. Ofosu-Anim and A. Mawuli. 2012. Gibberellic acid and naphthalene acetic acid affect fruit retention, yield and quality of Keitt mangoes in the coastal savanna ecological zone of Ghana. Am. J. Plant Physiol. 7: 243-251.

Plaza, A., P. Martínez, J. Plaza and R. Pérez. 2005. Dimensionality reduction and classification of hyperspectral image data using sequences of extended morphological transformations. IEEE Trans. Geosci. Remote Sens. 43: 466-479.

Priya, B.N.V., K. Mahavishnan, D.S. Gurumurthy, H. Bindumadhava, A.P. Upadhyay and N.K. Sharama. 2014. Fulvic acid (FA) for enhanced nutrient uptake and growth: insights from biochemical and genomic studies. J. Crop Improv. 28: 740-757.

Ram, S. 1992. Naturally occurring hormones of mango and their role in growth and drop of fruit. Acta Hort. 321:400–411.

Ram, S. 2000. Hormonal control of fruit growth and fruit drop in mango cv. Dashehari. Acta Hort. 509: 137-149.

Shaheen, M.G., S.M. Abdel-Wahab, E.A. Hassan and A.M.R.A. AbdelAziz. 2012. Effect of some soil conditioners and organic fertilizers on vegetative growth and quality of Crimson seedless grapevines. J. Hortic. Sci. Ornam. Plants 4: 260-266.

Steel, R.G.D. and J.H. Torrie. 1984. Principles and Procedures of Statistics: A Biometrical Approach. 2nd McGraw Hill Book Co., Singapore.

Suh, H.Y., K.S. Yoo and S.G. Suh. 2014. Effect of foliar application of fulvic acid on plant growth and fruit quality of tomato (*Lycopersicon esculentum* L.). Hortic. Environ. Biotechnol. 55: 455-461.

Summer, M.E. 1985. Diagnosis and Recommendation integrated System (DRIS) as a Guide of orchard Fertilization. Hort. Abst. 55, 7502.

Vejendla, V., P.K. Maity and B.C. Banik. 2008. Effect of chemicals and growth regulators on fruit retention, yield and quality of mango cv. Amrapali. J. Crop Weed 4: 45-46.

Von-Wettstein, D.V. 1957. Chlroophyll- Lethale under submikroshopische formilkechrel der plastiden celi, prp. Trop. Res. Amer. Soc. Hort. Sci. 20: 427- 433.

Wang, Y., R.Yang, J. Zheng, Z. Shen and X. Xu. 2019. Exogenous foliar application of fulvic acid alleviate cadmium toxicity in lettuce (*Lactuca sativa* L.). Ecotoxicol. Environ. Saf.167: 10-19.

Wilde, S.A., R.B. Corey, J.G. Layer and G.K. Voigt. 1985. Soils and plant analysis for tree culture. Oxford, IBH, New Delhi, India, 1-130.

Zancani, M., A. Bertolini, E. Petrussa, J. Krajňáková, A. Piccolo, R. Spaccini and A. Vianello. 2011. Fulvic acid affects proliferation and maturation phases in Abies cephalonica embryogenic cells. J. Plant Physiol. 168: 1226-1233.

Zhang, L., J.U.N. Zhou, Y.G. Zhao, Y. Zhai, K.A.I. Wang, A.K. Alva and S. Paramasivam. 2013. Optimal combination of chemical compound fertilizer and humic acid to improve soil and leaf properties, yield and quality of apple (*Malus domestica*) in the loess plateau of China. Pak. J. Bot. 45: 1315-1320.

الملخص العربي

دراسة تأثير الرش الورقي ب NAA وحمض الفولفيك على النمو الخضري والمحصول وجودة الثمار لأشجار المانجو صنف التيمور

محمد احمد حسين، عماد الدين حافظ عبدالعال واسراء محمود السيد

أجريت هذه الدراسة على أشجار المانجو صنف التيمور البالغة من العمر ١٦ عام في مزرعة خاصة بمحافظة سوهاج خلال مواسم ٢٠١٩ و٢٠٢٠ و٢٠٢١ لدراسة تأثير الرش الورقى بحمض الفولفيك بتركيز (١٠٠٠ و٢٠٠٠ و٣٠٠٠ جزء في المليون) و NAA بتركيز (١٥ و٣٠ و٤٥ جزء في المليون) على مساحة الورقة وتركيبها الكيميائي والمحصول، نسبة الثمار المتبقية وجودة الثمار. تم رش الأشجار المختارة ثلاث مرات ب NAA قبل التزهير وأثناء التزهير الكامل وبعد العقد، ورش حمض الفولفيك ثلاث مرات قبل التزهير، بعد عقد الثمار وبعد شهرمن الرشة الثانية.

أشارت نتائج الدراسة إلى أن الرش الورقى بحمض الفولفيك بتركيز (١٠٠٠، ٢٠٠٠، ٣٠٠٠ جزء في المليون) و NAA بتركيز (١٥، ٣٠ و٤٥ جزء في المليون) بصورة مفردة أو مشتركة إلى تحسين مساحة الورقة وتركيبها الكيميائي والمحصول، نسبة الثمار المتبقية، جودة الثمار وانخفاض في النسبة المئوية للحموضة.

كان استخدام حمض الفولفيك أفضل من استخدام NAA لتحسين مساحة الورقة ومحتواها الكيميائي ولكن كان استخدام NAA أفضل من استخدام حمض الفولفيك لتحسين المحصول نسبة الثمار المتبقية وجودة الثمار. كان تأثير المعاملة المشتركة أفضل من استخدام كل مادة على حدة.

تم الحصول على أفضل النتائج عن طريق معاملة أشجار المانجو صنف التيمور ثلاث مرات (قبل التزهير، بعد عقد الثمار وبعد شهرمن الرشة الثانية) بحمض الفولفيك بتركيز ٣٠٠٠ جزء في المليون بالإضافة الى رشNAA بتركيز ٤٥ جزء في المليون ثلاث مرات (قبل التزهير، أثناءالتزهير الكامل وبعد العقد) والتي سجلت أعلى القيم في المواسم الثلاثة المدروسة مقارنة بجميع المعاملات.

الكلمات المفتاحية: NAA، حمض الفولفيك، جودة ثمار المانجو صنف التيمور.