Effect of Amino Acids, Mono-Potassium Phosphate, and Calcium Foliar Application on Flowering, Yield, and Fruit Quality of Mango "Ewaise" Cultivar

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ABSTRACT

"Ewaise" mango is the most delicious mango variety in Egypt. It is very popular. However, it suffers from low fruit yield. The shortage of yield may be due to the adverse effects of unfavorable environmental conditions. Mono-potassium phosphate, calcium, and amino acids are proven to improve these negative effects. During the 2020/2021 and 2021/2022 seasons, a study was conducted to investigate the impact of the application of 2% mono-potassium phosphate, 2000 ppm calcium, and 1000 ppm amino acids alone or in combination treatments on blooming characteristics, shoot length, leaf area, N, P, K, Fe, Mn, total chlorophylls, total carotenoids in the leaves, yield, as well as some physical and chemical characteristics of the fruits of "Ewaise" mango trees. The results showed that foliar application of 2% mono-potassium phosphate, 2000 ppm calcium, and 1000 ppm amino acids either individually or in combination significantly improves flowering, growth, nutrient levels (including N, P, K, Fe, and Mn), total chlorophylls, total carotenoids in the leaves, yield, and fruit quality, compared to a control treatment. In terms of the best order of application, using the 1000 ppm amino acids, 2% mono-potassium phosphate, and 2000 ppm calcium in descending order was crucial in achieving these positive outcomes. Combined applications of these materials were significantly more effective than using each material alone in improving the mentioned aspects. Specifically, carrying out four sprays (1st week of November, the 1st week of December, after the fruit set, and one month later) of 1000 ppm amino acids plus 2% mono-potassium phosphate plus 2000 ppm calcium yielded the best results in terms of yield and fruit quality of "Ewaise" mango trees.

Keywords: mono-potassium phosphate, calcium, amino acids, yield, "Ewaise" mango trees.

INTRODUCTION

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae and is considered one of the most important fruits of the tropical and subtropical countries of the world (Murti and Uprti, 2000). It grows under a wide range of climatic and soil conditions (Mohamed *et al.,* 2016). In Egypt, mango ranks second after citrus, whereas its total area of fruitful orchards reached approximately 294100 fed. Producing about 766128 tons of fruits (Egyptian Ministry of Agriculture, 2021). However, the decline in yield of mango trees grown under Sohag region conditions is considered serious. Today's major problems facing mango growers are low fruit set percentage, yield, and inferior fruit quality. One of the most important factors responsible for low yield is inadequate pollination and less fertilization which causes less fruit set and high fruit drop. Overcoming this problem with some nutrients was useful for improving the setting of fruits, fruit quality, and yield. Several researchers made attempts to enhance the productivity and quality of mangoes via foliar applications of mono-potassium phosphate, calcium, and amino acid to increase the mango tree's ability to resistance various stresses that lead to poor yield. Additionally, spraying potassium can positively impact fruit set, fruit retention, yield, and fruit quality, according to Oothuyes (1993). Potassium is an essential plant nutrient that plays an important role in the growth and development of mango trees. Its foliar application has been proven to improve both productivity and fruit quality. This substance is crucial for photosynthesis, enzyme activity, and protein synthesis, carb synthesis, fat synthesis and helps plants resist pests and diseases (Mehdi *et al.,* 2007). Potassium plays a significant role in improving crop quality. Additionally, phosphorus is a crucial and irreplaceable component of various structural elements. Its absence can lead to metabolic disruptions in plants, as noted by Pandita and Andrew (1967). Phosphorus is crucial for plant energy transfer, photosynthesis, sugar and starch conversion, and nutrient movement (Hiller, 1995 and Taha, 2016). Amino acids play a crucial role in a plant's primary and secondary metabolism (do C. Mouco *et al.,* 2009), specifically in synthesizing important compounds for fruit quality and production. For instance, the balance of phenolic compounds is critical for fruit composition, such as in mangoes. Phenylalanine amino acid is responsible for producing the main pigment for fruit coloring (anthocyanin). Asparagine amino acid and glutamate connect the carbon and nitrogen metabolic cycles, which influence both sugars and proteins. Meanwhile, glycine is an amino acid that benefits C3 plants like mango trees, as it inhibits photorespiration and promotes photosynthesis efficiency, resulting in higher sugar content and yield, according to Taiz & Zeiger (2002); Khattab *et al*. (2016) and Ali *et al.* (2019).

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Calcium is an important nutrient for plants that helps protect them from stress and plays a key role in numerous physiological functions, according to Bhatt *et al.* (2012). By foliar application of calcium, productivity can be increased by reducing fruit abscission and improving the quality of mango fruits. This is achieved by maintaining the middle lamella cells and increasing firmness, as supported by studies (Karemera *et al*., 2013 and Mounika *et al*., 2021).

This research investigates the effect of foliar application of a 2% solution of mono-potassium phosphate, 2000 ppm calcium, and 1000 ppm amino acid, either individually or in combination, on the growth, blooming characteristics, yield, and fruit quality of “Ewaise” mango trees.

MATERIALS AND METHODS

The study was conducted during two successive seasons, namely 2020/2021 and 2021/2022, on 24 “Ewaise” mango trees (*Mangifera indica* L.) that were 20 years old. These trees were budded on seedling rootstock and planted a spacing of 7 x 7 meters apart in silty clay soil with a surface irrigation system in a private orchard in the Tema district of the Sohag Governorate in Upper Egypt, where table (1) shows the physical and chemical analysis of the tested orchard soil. The trees received a basal recommended fertilizer and were subjected to annual agricultural practices. The chosen trees were healthy and had nearly uniform vigour. All the trees were arranged in a complete randomized block layout with three replicates, with one tree assigned to each replicate.

The treatments were subjected as follows:

T1= control.

T2= spraying 2 % mono-potassium phosphate.

T3= spraying 2000 ppm calcium.

T4= spraying 1000 ppm amino acids.

T5= spraying 2 % mono-potassium phosphate + 2000 ppm calcium.

T6= spraying 2 % mono-potassium phosphate + 1000 ppm amino acids.

T7= spraying 2000 ppm calcium + 1000 ppm amino acids.

T8= spraying 2 % mono-potassium phosphate + 2000 ppm calcium + 1000 ppm amino acids.

To enhance tree growth and fruit production, the trees under investigation were sprayed with Bioflow (a commercial compound containing 27.3 % amino acids) at 1000 ppm, mono-potassium phosphate (a commercial product produced by Tabarak Company containing 52% P and 34% K) at 2 % and calcium were added as a solution Stopit (a commercial product produced by Yara Company South Africa, containing 16% ca) at 2000 ppm. Each treatment was replicated three times, with one tree per replication. The trees were sprayed four times during both seasons (1st week of November, the 1st week of December, after the fruit set, and one month later). All solutions, including amino acids, mono-potassium phosphate, and calcium, were mixed with Triton B, a wetting agent, at 0.05%. Spraying was done until runoff using 10 L water per tree. The twenty-four trees selected for this study received the same horticultural practices in the orchard.

Table 1. Physical and chemical analysis of the tested orchard soil

Soil properties	
Sand %	10.50
Silt %	53.20
Clay	36.30
Texture	Silty clay
pH(1:2.5 extract)	7.62
EC (1: 2.5 extract) (mmhos/Icm/25ºC)	0.60
O.M. %	2.44
$CaCO_3$ %	1.55
Total N %	0.16
Available P (ppm, Olsen)	28
Available K (ppm/ ammonium acetate)	4.97
Available Mg (ppm)	144.00
Available S (ppm)	6.85
B (ppm) (hot water extractable)	0.25
Available EDTA extractable micronutrients (ppm)	
Zn	1.28
Fe	11.19
Mn	10.30
Cu	1.70

The following parameters were measured for both seasons:

Blooming characteristics:-

At the end of flowering, which occurred in the second week of April, we counted the total number of panicles per tree. Additionally, we measured the average length of 15 panicles from each replicate at the end of flowering. Average number of secondary branches per panicle was counted. The perfect flower percentage: PF (%) = (number of perfect flowers) divided by (total number of flowers) and then multiplied by 100.

Fruit set:-

Ten one-year-old shoots per tree were randomly selected and tagged for observation. The total number of flowers per panicle was counted at full bloom. Two weeks after the full bloom stage, the number of fruitlets per panicle was counted to determine the fruit set. The fruit set percentage (FS %) was calculated formula: FS (%) = (number of fruitlets/panicle at fruit set)/(number of flowers/panicle at full bloom) ×100.

Fruit retention percentage:-

Fruit retention was recorded in both seasons at the mature stage (a week before harvest). FR (%) = (number of fruit retention) divided by (number of initial fruit set) and then multiplied by 100.

Vegetative growth characteristics:-

- **Leaf area**:-Twenty leaves below panicles of the spring growth cycle according to Summer (1985) were taken (2^{nd} week of June) for measuring leaf area according of Ahmed and Morsy (1999).
- **Shoot length:-** In both seasons, four one-year-old branches were chosen for each tree, one toward each direction. Four shoots on each branch in the spring growth cycle were labeled for measuring shoot length (cm.).

Yield:-

At the mid-July harvest each season, the tree yield was harvested, the number of fruits per tree was counted, and the weight of the tree yield was measured Kg/tree.

Leaf mineral:-

Twenty mature leaves (7 months- old) were picked from nonfruiting shoots in the spring growth cycle of each tree (1st week of July) **(**Summer, 1985**)**. N, P, and K as percentages, Fe, and Mn as ppm on the dry weight basis were determined using the standard methods outlined by Wilde ***et al***. (1985)**.**

Total chlorophylls and Total carotenoids (mg/ 1.0 g F.W.) were measured spectrophotometrically according to Wettstein, 1957 as follows: 200 mg of fresh leaves tissues were ground in 90% acetone. Absorptions were taken at 663 nm and 644 nm for chlorophylls and 452.5 nm for carotenoids, and the following equations were used (Wellburn and Lichtenthaler, 1984).

Fruit quality:

At harvest time, a sample of 10 fruits from each tree was taken to assess their physical and chemical properties. The following properties were determined: -

- **Physical properties**:

  Fruit weight (measured in gram)
- **Chemical properties:**

  Total soluble solids percentage (TSS %) was measured using a hand refract meter. Acidity % was determined as citric acid content using fresh juice with titration against 0.1 Na OH. Percentage of total sugars, reducing sugars and vitamin C content (as mg/ 100 ml juice) (A.O.A.C., 1995).

Statistical analysis:

All the obtained data were tabulated and statistically analyzed according to Mead *et al.* (1993). The averages of different treatments were compared using the new L.S.D. test at 5% according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Blooming characteristics:-

Table (2) presents the results of the blooming characteristics, including the total number of panicles per tree, panicle length, secondary branches per panicle, and the percentage of perfect flowers. The application of mono-potassium phosphate, calcium, and amino acids via foliar application, either alone or in combinations, resulted in significant improvements compared to the control treatment. The treatments led to a significant increase in the percentage of perfect flowers. There were notable differences observed in these parameters among the treatments. Particularly, the combination of 1000 ppm amino acids, 2% mono-potassium phosphate, and 2000 ppm calcium, applied in descending order, showed significant positive effects on the blooming characteristics. The combined applications of these materials were more effective than using each material alone in enhancing the flowering aspects, including the total number of panicles per tree, panicle length, secondary branches per panicle, and percentage of perfect flowers. The highest values for total number of panicles per tree (244.83 and 290.33 panicles/tree), average panicle length (37.42 and 41.42 cm), secondary branches per panicle (19.00 and 20.89 branches/panicle), and perfect flowers percentage (22.43 and 26.13%) were recorded in trees treated with

2% mono-potassium phosphate plus 2000 ppm calcium in four sprays, along with 1000 ppm amino acids applied four times. On the other hand, the untreated trees exhibited the lowest values. These results were consistent throughout both seasons. Nutrient application through spraying on mango trees plays a vital role in promoting growth, yield, fruit quality, and disease control. Numerous studies have confirmed that foliar application of specific nutrients can significantly increase productivity and enhance fruit quality. In particular, the application of a high concentration of calcium and boron solution has been found to boost the number of hermaphrodite flowers in the Mahachanok mango cultivar. This is attributed to the longer inflorescence resulting from the solution, consequently leading to improved fruit set, yield, and fruit quality. Additionally, studies conducted by Khattab *et al*. (2016) and Maklad *et al*. (2020) have explored the use of both macro and micronutrients for similar purposes.

Vegetative growth characteristics:-

The data in Table (3) shows that single and combined applications of mono-potassium phosphate, calcium, and amino acids significantly stimulated shoot length and leaf area relative to the control. Combined applications of these materials were significantly more favorable than using them alone. The promotion significantly depended on using 100 ppm amino acids, 2 % Mono-potassium phosphate, and 2000 ppm calcium in descending order to enhance the shoot length and leaf area. Treatment of mono-potassium phosphate plus amino acids was superior to treatments of mono-potassium phosphate plus calcium and calcium + amino acids. The maximum values were recorded on the trees that received 2 % mono-potassium phosphate + 2000 ppm calcium + 1000 ppm amino acids. The untreated trees produced the lowest values. A similar trend was noticed during both seasons. Several studies have shown that using mono-potassium phosphate for foliar application can improve the growth characteristics of plants. Similar findings were reported by Abd El-Rahman (2015) for Keitte mango trees, Abd El-Gawad *et al*. (2017) for Hindi Khasa mango trees, and El-Gioushy (2016) for Orange trees. All three studies found that using potassium silicate treatments for foliar application resulted in significantly improved vegetative growth compared to the control. Similarly, Wassel *et al*. (2015) found the same trend in amino acid results when studying 'wonderful' pomegranate trees. In another study by El-Kosary *et al*. (2011), the application of amino acids treatment on certain mango cultivars resulted in a significant increase in the number of growth cycles compared to other treatments.

Leaf chemical composition

Tables (3&4) present the results of the amount of total chlorophylls, total carotenoids, and nutrient contents of leaves, including N, P, K (as a percentage), Fe (ppm), and Mn (ppm). The application of mono-potassium phosphate, calcium, and amino acids via foliar application, either alone or in combinations, resulted in significant improvements compared to the control treatment. The treatments led to a significant increase in the amount of total chlorophylls, total carotenoids, and nutrient contents of leaves, including N, P, K (as a percentage), Fe (ppm), and Mn (ppm). There were notable differences observed in these parameters among the treatments. Particularly, the combination of 1000 ppm amino acids, 2% mono-potassium phosphate, and 2000 ppm calcium, applied in descending order, showed significant positive effects on the amount of total chlorophylls, total carotenoids, and nutrient contents of leaves, including N, P, K, (as a percentage), Fe (ppm), and Mn (ppm). The combined applications of these materials were more effective than using each material alone in enhancing the amount of total chlorophylls, total carotenoids, and nutrient contents of leaves, including N, P, K, (as a percentage), Fe (ppm), and Mn (ppm). The highest values for total chlorophylls, total carotenoids, and nutrient contents of leaves, including N, P, K (as a percentage), Fe (ppm), and Mn (ppm), were recorded in trees treated with 2% mono-potassium phosphate plus 2000 ppm calcium in four sprays, along with 1000 ppm amino acids applied four times. On the other hand, the untreated trees exhibited the lowest values. These results were consistent throughout both seasons. Researches have shown that mono potassium phosphate (MKP) can positively impact leaf mineral content in mango trees. Studies by Sanna & Abd El-Migeed (2005); Sarrwy *et al.* (2012); El-Razek *et al*. (2013); Taha *et al.* (2014), and Baiea *et al.* (2015) have all found that different forms of potassium applied through foliar sprays can increase nitrogen, phosphorus, and potassium levels in leaves. This is due to the shorter uptake time compared to soil application. Similarly, amino acid treatments have been found to increase growth cycles in some mango cultivars according to research by El-Kosary *et al*. (2011), which aligns with the findings of Fry (2004) and Mosa *et al.* (2015). Research on 'wonderful' pomegranate trees by Wassel *et al*. (2015) has also shown similar trends in amino acid results.

Table 2. Effect of mono-potassium phosphate, calcium and amino acid foliar application on some blooming characteristics of "Ewaise" mango trees cv

Treatments	Total number of panicles/ tree		Average panicle length (cm)		Secondary branches/ panicles		Perfect flowers percentage	
	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
Control	112.70±3.98	148.33±6.01	22.50±0.50	23.63±0.63	11.39±0.20	13.0±0.33	12.30±0.58	16.20±0.68
2 % Mono-potassium phosphate (MKP)	140.55±2.21	188.00±3.71	24.82±0.11	25.42±0.47	13.11±0.00	14.89±0.44	15.13±0.28	18.53±0.40
2000 ppm Calcium (Ca)	123.13±6.17	172.67±2.00	23.88±0.24	24.37±0.12	12.67±0.11	14.57±0.33	14.80±0.42	18.70±0.52
1000 ppm amino acids (AA)	169.99±5.78	204.00±3.05	25.79±0.32	26.37±0.42	14.33±0.33	14.78±0.33	15.80±0.29	19.57±0.40
2 % MKP + 2000 ppm Ca	203.64±1.18	260.60±9.83	31.66±0.22	33.30±0.24	16.78±0.11	18.57±0.55	17.96±0.18	21.86±0.54
2 % MKP + 1000 ppm AA	221.94±0.88	273.00±2.38	35.50±0.18	38.75±2..30	17.94±0.11	19.97±0.29	19.43±0.34	23.93±0.42
2000 ppm Ca +1000 ppm AA	194.80±1.24	237.67±3.51	26.82±0.50	27.99±0.59	15.89±0.36	16.45±0.36	16.76±0.28	20.67±0.29
2 % MKP+2000 ppm Ca+1000 ppm AA	244.83±7.21	290.33±3.18	37.42±0.54	41.42±0.35	19.00±0.19	20.89±0.22	22.43±0.47	26.13±1.05
New LSD at 5 %	12.11	13.66	2.09	2.69	0.58	2.58	1.04	1.04

Table 3. Effect of mono-potassium phosphate, calcium and amino acid foliar application on shoot length, leaf area, total chlorophylls and total carotenoids of "Ewaise" mango trees cv

Treatments	Shoot length (cm)		Leaf area (cm^2)		Total chlorophylls (mg/g F.W)		Total carotenoides (mg/ g F.W.)	
	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
Control	9.55±0.40	9.27±0.27	78.10±2.40	80.60±0.53	1.17±0.04	1.25±0.03	0.57±0.04	0.50±0.02
2 % mono-potassium phosphate (MKP)	12.33±0.40	11.67±0.28	82.70±3.04	84.26±1.60	1.34±0.01	1.42±0.02	0.62±0.02	0.56±0.01
2000 ppm calcium (Ca)	10.23±0.30	10.00±0.44	81.30±2.61	81.83±2.46	1.28±0.02	1.37±0.04	0.58±0.03	0.56±0.05
1000 ppm amino acids (AA)	13.17±0.50	12.67±0.50	83.76±2.04	85.13±3.91	1.39±0.01	1.43±0.04	0.62±0.01	0.62±0.02
2 % MKP + 2000 ppm Ca	14.77±0.40	13.94±0.24	85.70±3.18	86.90±2.54	1.46±0.01	1.51±0.01	0.70±0.01	0.62±0.03
2 % MKP + 1000 ppm AA	17.64±0.30	16.64±0.33	89.30±2.27	89.76±1.35	1.60±0.03	1.65±0.05	0.83±0.02	0.70±0.02
2000 ppm Ca +1000 ppm AA	16.33±0.15	15.33±0.19	87.56±0.60	88.76±1.40	1.55±0.02	1.60±0.03	0.70±0.02	0.68±0.06
2 % MKP+2000 ppm Ca+1000 ppm AA	18.56±0.29	17.56±0.29	91.26±0.77	91.86±1.62	1.63±0.01	1.65±0.02	0.84±0.01	0.81±0.03
New LSD at 5 %	0.42	0.42	3.54	3.34	0.001	0.002	0.06	0.05

Table 4. Effect of mono-potassium phosphate, calcium and amino acids foliar application on the leaf chemical composition of "Ewaise" mango trees cv

Treatments	N %		P %		K %		Leaf Fe content (ppm)		Leaf Mn content (ppm)	
	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
Control	1.43 ±0.04	1.40 ±0.03	0.11 ±0.01	0.12±0.003	0.80±0.017	0.80±0.022	90.0 ±1.73	96.0 ±1.76	66.3 ±1.85	67.5 ±4.04
2 % mono-potassium phosphate (MKP)	1.59 ±0.01	1.50 ±0.02	0.17±0.006	0.18±0.002	0.90±0.003	0.92±0.028	107.3±3.95	108.6±2.40	72.3 ±1.45	73.3 ±2.89
2000 ppm calcium (Ca)	1.50 ±0.01	1.45 ±0.01	0.14±0.005	0.15±0.001	0.83±0.006	0.84±0.006	95.0 ±4.04	100.0±3.21	69 ±5.20	70 ±5.78
1000 ppm amino acids (AA)	1.55 ±0.02	1.48 ±0.03	0.15±0.006	0.16±0.003	0.87±0.003	0.89±0.023	102.0±1.00	104.5±2.46	69 ±2.90	70.5 ±2.90
2 % MKP + 2000 ppm Ca	1.69 ±0.01	1.60 ±0.02	0.19±0.007	0.20±0.004	0.99±0.008	0.90±0.026	115.0±7.64	117.9±7.51	75 ±3.18	77 ±4.04
2 % MKP + 1000 ppm AA	1.75 ±0.01	1.69 ±0.01	0.23±0.014	0.22±0.005	1.06±0.008	1.05±0.011	119.0±5.20	122.0±3.60	75.3 ±2.64	78 ±1.73
2000 ppm Ca +1000 ppm AA	1.63 ±0.01	1.55 ±0.07	0.18±0.008	0.19±0.003	0.93±0.008	0.95±0.014	111.0±5.51	113.8±4.04	72.3 ±1.73	74 ±2.31
2 % MKP+2000 ppm Ca+1000 ppm AA	1.79 ±0.01	1.72 ±0.01	0.26±0.023	0.25±0.008	0.80±0.006	1.09±0.023	120.0±2.89	126.8±2.52	78.9 ±4.62	82.5 ±4.16
New LSD at 5 %	0.001	0.001	0.001	0.001	0.002	0.002	3.60	3.50	1.6	1.8

Table 5. Effect of mono-potassium phosphate, calcium and amino acid foliar application on Percentages of fruit set, fruit retention, yield and fruit weight of "Ewaise" mango trees cv

Treatments	Fruit set (%)		Fruit retention (%)		yield / tree (kg)		Fruit weight (g)	
	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
Control	4.43 ±0.12	5.28 ±0.09	1.95 ±0.03	2.11 ±0.02	39.700 ±2.31	47.20 ±0.2.31	185.13±7.42	191.00±3.06
2 % mono-potassium phosphate (MKP)	4.63 ±0.01	5.42 ±0.02	2.17 ±0.04	2.37 ±0.02	50.200 ±2.70	56.133±0.4.53	198.33±2.40	202.36±5.03
2000 ppm calcium (Ca)	5.04 ±0.04	6.02 ±0.04	2.41 ±0.01	2.57 ±0.01	45.800 ±3.11	52.633±0.3.07	189.90±1.16	196.00±1.25
1000 ppm amino acids (AA)	4.97 ±0.08	5.89 ±0.06	2.27 ±0.02	2.49 ±0.02	48.633 ±5.41	54.200±0.2.01	195.20±5.78	200.33±2.86
2 % MKP + 2000 ppm Ca	5.28 ±0.01	6.47 ±0.16	2.43 ±0.01	2.63 ±0.01	51.767 ±6.05	56.900 ±0.36	200.67±0.33	204.50±4.01
2 % MKP + 1000 ppm AA	5.65 ±0.03	7.38 ±0.46	2.48 ±0.02	2.66 ±0.01	55.333 ±5.03	59.833±0.2.18	207.33±5.52	210.17±3.21
2000 ppm Ca +1000 ppm AA	5.97 ±0.13	8.87 ±0.17	2.49 ±0.03	2.71 ±0.02	52.833 ±2.52	58.367 ±0.3.43	204.00±5.51	206.50±2.57
2 % MKP+2000 ppm Ca+1000 ppm AA	6.31 ±0.14	9.28 ±0.12	2.52 ±0.01	2.75 ±0.01	56.800 ±4.10	61.200 ±0.52	211.37±3.32	214.17±3.88
New LSD at 5 %	0.01	0.14	0.001	0.001	1.50	1.14	3.86	5.32

Percentages of initial fruit setting and fruit retention

It is evident from the obtained data in Table (5) that single and combined applications of mono-potassium phosphate, calcium, and amino acid caused a significant promotion in the percentages of fruit setting and fruit retention relative to the control. Using calcium was significantly preferable to using mono-potassium phosphate and amino acid in improving fruit setting and fruit retention. Combined applications were significantly favourable than using each material alone in this respect. The maximum fruit setting (6.31 and 9.28 %) and fruit retention (2.52 and 2.75 %) were recorded on the trees that received four Spays of 2 % mono-potassium phosphate + 2000 ppm calcium + 1000 ppm amino acids during both seasons, respectively. The untreated trees produced the lowest values of fruit setting (4.43 and 5.58 %) and fruit retention (1.95 and 2.11 %) during both seasons, respectively. These results were true during both seasons. Calcium, potassium and amino acids positively affected increasing fruit set %. The reason for this improvement may be attributed to the efficacy of these treatments in enhancing nutritional status, leading to higher rates of fruit set and retention. This has been corroborated by the findings of Mosa *et al*. (2015), who demonstrated that calcium nitrate had a significant impact on increasing fruit set in the "Le Conte" pear tree in comparison to the control. Calcium increased fruit set by improving photosynthesis availability and promoting auxin synthesis, which is crucial for fruit growth and development (Kazemi, 2014).

Yield/tree

Table (5) presents the results of the yield per tree. The application of mono-potassium phosphate, calcium, and amino acids via foliar application, either alone or in combinations, resulted in significant improvements compared to the control treatment. The treatments led to a significant increase in the yield per tree. There were notable differences observed in these parameters among the treatments. Particularly, the combination of 1000 ppm amino acids, 2% mono-potassium phosphate, and 2000 ppm calcium, applied in descending order, significantly positively affected the yield per tree. The combined applications of these materials were more effective than using each material alone in enhancing the yield per tree. The highest values for the yield per tree (56.800 and 61.200 kg/tree) were recorded in trees treated with 2% mono-potassium phosphate plus 2000 ppm calcium in four sprays, along with 1000 ppm amino acids applied four times. On the other hand, the untreated trees exhibited the lowest values (39.70 and 47.20 Kg/tree). These results were consistent throughout both seasons. Potassium treatments significantly impact tree yield as they catalyze various biological processes within trees, leading to improved nutritional status. This is consistent with the findings of Abd El-Razek *et al*. (2013) and Taha *et al*. (2014), who observed that spraying mango trees with potassium increased fruit number per tree, resulting in higher tree yield and maximum productivity. The results on amino acid align with similar findings from research on Flame seedless grapevines by Belel *et al*. (2016), Ewais and Fagry Kelan mango trees by Khattab *et al*. (2016), and Keitte mango trees by Haikal and Gomaa (2017). All studies showed that the use of amino acids improved fruit yield parameters. The increase in fruit yield when using the foliar application of calcium helps increase the fruit set. Our findings align with Saher (2014), who studied the “Ewaise” mango cultivar and found that applying calcium at 4000 ppm led to the highest number of fruits and yield per tree, compared to using zinc at 2000 ppm. Singh *et al*. (2017), found that mango nutrition with calcium, boron, and zinc positively affects flower initiation and leads to higher yield.

Fruit Quality

It is evident from Tables (5) and (6) that treating “Ewaise” mango trees four times with mono-potassium phosphate, calcium, and amino acids either alone or in combination applications significantly improved fruit quality. This resulted in an increase in fruit weight, TSS % (except in the second season, where the increase was insignificant), total and reducing sugars %, vitamin C content, and a reduction in total acidity % compared to the check treatment. Using 1000 ppm amino acid, 2 % mono-potassium phosphate, and 2000 ppm calcium, in descending order, was essential in promoting fruit quality. Using a combination of mono-potassium phosphate, calcium, and amino acid is more effective in improving fruit quality than using each material individually. The trees sprayed with 2% mono-potassium phosphate, 2000 ppm calcium, and 1000 ppm amino acids had the highest recorded values. Unfavorable effects on fruit quality were recorded on the control trees. The results were true during both seasons. Research conducted by Ahmad *et al.* (2013) and Ahmed *et al.* (2013) on Hindy Bisinnara mango trees and Faissal *et al*. (2014) on Keitte mango trees found that the application of Potassium leads to an increase in TSS and vitamin C and a decrease in juice acidity.

Table 6. Effect of mono-potassium phosphate, calcium and amino acid foliar application on fruit Quality of "Ewaise" mango trees cv

Treatments	TSS %		Total acidity %		Total sugars %		Reducing sugars %		ascorbic acid content (V.C mg/100g juice)	
	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
Control	15.27 ±1.84	17.13 ±1.19	0.394 ±0.02	0.379±0.01	15.13±1.12	14.00 ±1.75	7.16 ±0.02	7.53 ±0.32	30.96±0.69	32.60±0.92
2 % mono-potassium phosphate (MKP)	18.76±0.03	19.00 ±0.11	0.355 ±0.03	0.332 ±0.02	17.13 ±0.12	17.46 ±0.06	7.70 ±0.01	7.86 ±0.24	34.76 ±0.40	35.73±0.45
2000 ppm calcium (Ca)	18.00±0.16	18.30±0.20	0.373±0.03	0.356 ±0.01	16.63 ±0.06	16.33±1.23	7.50 ±0.10	7.60 ±0.10	32.86 ±0.36	34.00±0.35
1000 ppm amino acids (AA)	18.50 ±0.01	18.86 ±0.08	0.360 ±0.02	0.347 ±0.03	16.93 ±0.05	17.03 ±0.62	7.63 ±0.24	7.60 ±0.05	33.70 ±0.23	35.20±0.06
2 % MKP + 2000 ppm Ca	19.40 ±0.01	19.73 ±0.12	0.305 ±.04	0.299 ±0.01	17.70 ±0.01	17.93 ±0.12	8.56 ±0.26	8.70 ±0.11	36.70±0.02	37.96±0.05
2 % MKP + 1000 ppm AA	19.26±0.03	17.20 ±0.03	0.320±0.01	0.306 ±0.03	17.53 ±0.12	17.63 ±0.58	8.16 ±0.26	8.43 ±0.08	35.90±0.80	37.06±0.02
2000 ppm Ca +1000 ppm AA	19.03±0.03	19.36 ±2.25	0.332 ±0.01	0.329±0.01	17.40±0.01	17.76 ±0.32	7.73 ±0.06	7.83 ±0.18	34.96 ±0.05	36.00±0.70
2 % MKP+2000 ppm Ca+1000 ppm AA	19.63±0.21	19.96 ±0.21	0.277 ±0.02	0.275±0.02	17.86 ±0.03	17.90 ±0.52	9.91 ±0.82	10.80±0.88	37.73±0.50	38.53±0.23
New LSD at 5 %	1.63	N.S	0.001	0.001	1.12	1.81	0.10	0.41	0.28	0.28

According to researchers, Potassium is crucial in improving the chemical properties of fruits. As stated by Saleh and Abd El-Moneim (2003), it enhances the sugar formation and accumulation rate. Abd El-Razek *et al.* (2013) also observed similar results, showing that adding Potassium improved the chemical properties of mango fruits, including TSS, total acidity, and vitamin C. Similarly, Kumar *et al.* (2006) discovered that Potassium has a significant impact on the chemical properties of the fruit. The application of amino acids to the leaves of pistachio trees has been found to impact the levels of soluble solids, acidity, and vitamin C. This finding is consistent with the research conducted by Rahdari *et al*. (2012).

In conclusion, based on the results of the present study, it can be concluded that applying four sprays of three materials, namely 2% mono-potassium phosphate, 2000 ppm calcium, and 1000 ppm amino acids together, was effective in enhancing both the quantitative and qualitative aspects of yield in "Ewaise" mango trees.

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الملخص العربي

تأثير الرش الورقى بالأحماض الأمينية، فوسفات أحادي البوتاسيوم والكالسيوم على بعض الصفات الخضرية والزهرية، المحصول وجودة الثمار في أشجار المانجو صنف عويس

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تم خلال موسمي ٢٠٢٠/٢٠٢١ و ٢٠٢١/٢٠٢٢ معاملة أشجار المانجو صنف عويس بفوسفات أحادي البوتاسيوم بتركيز٢ %، الكالسيوم بتركيز ٢٠٠٠ جزء في المليون و الأحماض الأمينية بتركيز ١٠٠٠ جزء في المليون (رش أربعة مرات) وكان هدف هذه الدراسة اختبار تأثير هذه المعاملات على النمو الخضرى، التزهير، محتوى الأوراق من (العناصر الغذائية، الكلورفيل الكلى و الكاروتين الكلى) نسبة العقد، نسبة الثمار المتبقية، المحصول، الخصائص الفيزيائية و الكيميائية للثمار في أشجار المانجو صنف عويس.

أشارت نتائج الدراسة إلى أن الرش الورقي بفوسفات أحادي البوتاسيوم بتركيز٢ %، الكالسيوم بتركيز ٢٠٠٠ جزء في المليون و الأحماض الأمينية بتركيز ١٠٠٠ جزء في المليون (رش أربعة مرات) تؤدى إلى تحسين مساحة الورقة و طول الفرع و عدد النورات الزهريه و عدد الأزهار لكل نورة و طول النورة و عدد الأزهار الكاملة لكل نورة محتوى الأوراق من (العناصر الغذائية، الكلورفيل الكلى و الكاروتين الكلى) نسبة العقد، نسبة الثمار المتبقية، المحصول، الخصائص الفيزيائية و الكيميائية للثمار وذلك مقارنة بمعاملة الكنترول.

وكان التحسن عند استخدام ١٠٠٠ جزء في المليون من الأحماض الأمينية و ٢٪ فوسفات أحادي البوتاسيوم و ٢٠٠٠ جزء في المليون من الكالسيوم بترتيب تنازلي لتحسين جميع الصفات تحت الدراسة.

أمكن الحصول على أفضل النتائج بخصوص كمية المحصول وجودة الثمار فى أشجار المانجو صنف عويس عند الرش الورقي بفوسفات أحادي البوتاسيوم بتركيز٢ %، الكالسيوم بتركيز ٢٠٠٠ جزء في المليون و الأحماض الأمينية بتركيز ١٠٠٠ جزء في المليون أربعة مرات (أول شهر نوفمبر، أول شهر ديسمبر، بعد العقد و بعد العقد بشهر).

الكلمات المفتاحية: فوسفات أحادي البوتاسيوم؛ الكالسيوم؛ الأحماض الأمينية؛ المحصول؛ أشجار المانجو صنف عويس.