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Effect of foliar application of calcium, zinc and boron on growth and fruiting of Keitt mango trees

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Abstract

The current study was carried out over the course of three consecutive seasons in 2019–2020, and 2021 in a private mango orchard located in the Draw region of the Aswan governorate, where the soil is sandy. Zinc, boron, and calcium all play crucial roles. Mango tree growth and fruiting can therefore be enhanced by the balanced application and absorption of Ca, B, and Zn. to test the theory that foliar application of these nutrients in combination will improve the fruiting and vegetative growth of Keitt mango trees, a field study was carried out. Zinc, boron, and two Ca sources (Ca plus Zn and Ca plus B) in a single-state spring were investigated. 1ml/L of zinc, boron, or calcium in combination with either mineral was applied. The shoot length, leaf area, and leaf chlorophyll, as well as the yield, total soluble solids, sugar contents, panicle length, were all markedly enhanced by these treatments. The results showed that zinc and calcium worked better than other therapies. It has been determined that spraying calcium next to zinc or boron will enhance the growth and fruiting of Keitt mango trees.

Keywords: Keitt; Foliar application; Nutrients; Quality; Yield

Introduction

One of the most well-liked and well-known fruits in the world is the mango. It is commonly grown in tropical and subtropical areas and is regarded as the king of fruits. Egypt's mango-growing regions fed 321040 people, yielding a total of roughly 766128 tons of mangos **[1]**.

An imbalance in the nutrient supply causes poor plant health, low-quality fruit, and an increase in fruit drop in mangos. These issues are linked to fruit set, yield, and quality. Furthermore, illnesses and insect pests have an increased ability to target sick plants. several of researchers have previously attempted to apply nutrients topically to improve the quality and productivity of mangoes. Mango productivity is known to increase with calcium spray, primarily because of decreased abscission **[2] and [3].** It has been shown increased mango productivity when boron was applied **[4], [5] and** [6]. Fruit quality was also enhanced by the borate treatment in terms of weight, TSS, total sugars, and color **[7].** The observed effects on increased pollen germination, pollen tube expansion, and sugar production and accumulation may be ascribed to boron. Therefore, bearing in mind the significance of fruit set, production, quality, and nutrition.

Climate has a significant impact on the growth and fruiting of fruit trees. Mango productivity is beset with difficulties in tropical and subtropical regions of the world. Owing to shifting weather patterns **[8]**. Climate variables such as temperature, precipitation, light, humidity, and greenhouse gases can all have an impact on the mango phonological stage cycle **[9]**.

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Mango flowering may vary more than expected due to the predicted changes in temperature and the rising CO2 levels brought on by global warming, which could ultimately lead to low mango harvests. Mango flowering is inconsistent due to the climate, particularly the high temperatures during the flowering season **[10]**. Improving nitrogen availability and fertilizer use efficiency is required to maximize yields while reducing greenhouse gas emissions. Mangos have strong vegetative growth in the summer because to high temperatures, and in the winter, early flowering problems cause minimal yields. Mango yield will rise with increased fertilizer application, but fruit loss and flowering decline both of which are strongly impacted by climate—will not stop. Therefore, managing natural resources like water and nutrients in the face of climate change may be a way to stop the impending threat.

One of the most crucial factors in determining the quality of fruit is calcium. Cell elongation and division depend on it **[11]**.

Because of the calcic parent material in the soil, there is not much of a calcium deficiency, which makes it crucial for managing fruit problems. Poor dispersion following absorption may be the cause of the issue in plants **[12]**. Additionally, micronutrients are essential for the translocation of macronutrients and the operation of numerous metabolic processes in plants, including respiration, the growth of cell walls, the production of chlorophyll, photosynthesis, hormone synthesis, nitrogen fixation, and enzyme activity **[13]**. Zinc is a crucial trace element in many enzymatic processes, including the metabolism of proteins and carbohydrates as well as the growth and development of plants [**14**]. Even in situations where there is an abundance of B, many illnesses in fruits are related to B insufficiency, indicating that these disorders are physiological in nature and have to do with B's mobility throughout the plant tissues **[15]**.

The current study's goal was to ascertain how foliar application of zinc, boron, or calcium in combination with zinc or boron affected Keitt mango trees' growth, yield, and quality.

Materials and Methods

In a private mango orchard located in the Draw region of the Aswan governorate, where the soil is sandy and the water table is at least two meters deep, the current study was carried out over three consecutive seasons in 2019–2020, and 2021. The orchard soil analysis was done in accordance with [**16**] displayed in Table 1. For this study, eleven-year-old Keitt mango trees that were planted 3 by 4 meters apart and budded on mango seedling rootstocks were chosen. Using three replications and five nutrition treatments per tree, a randomized complete block design (RCBD) was implemented. Table 2 provides specifics about the nutrition interventions. For each of the three seasons, five foliar nutrition sprays were made on March 1 during the growth stage and May 15 following fruit setting. Every mango tree was given the standard agricultural and horticultural treatments that were already used in the orchard, such as weed, insect, and disease management, pruning, hoeing, and irrigation with Nile water.

During the two seasons under study, the following measurements were generally taken:

- Growth aspect measurements:

For every tree, ten 1.5-cm-diameter secondary branches were tagged in February. Using the following equation from [**17**]. twenty fresh shoots in the growth flush were selected in order to measure the shoot length (cm), number of leaves per shoot, and leaf area (cm2). L.A. = 0.70 (L x W) – 1.06, where L and W stand for maximum leaf length and width (cm), respectively, and L.A. = leaf area (cm^2). Chlorophyll content was measured by Chlorophyll meter (SPAD).

Table 1: The physical and chemical properties of the experimental site.

Characters	Value	Characters	Value
Particle size distribution		**Macronutrients values**	
Sand (%)	72.22	Total N (%)	0.09
Silt (%)	17.78	P (ppm, Olsen method)	5.1
Clay (%)	10.00	K (ppm, ammonium acetate)	69.9
Texture	Sandy	Mg (ppm)	10.9
pH (1:2.5 suspension)	8.11	EDTA extractable micronutrients (ppm)	
EC (1:2.5 extract) (mmh°s/1 cm/25-°C)	0.97	Zn	0.31
		Fe	0.60
Organic matter %	0.30	Mn	0.41
$CaCO_3$ (%)	1.29	Cu	0.22

Table 2. Details of the experimental nutrition treatments for the field application as foliar spray of mango cv. Keitt.

Treatments	Nutrition
T_1	Control (water spraying)
T_2	Spray with chelated with EDDTA zinc (13 zinc) 1 ml/L
T_3	Spray with Ca (6%) + Zn (1%) at 1 ml/L (InCa)
T_4	Spray with boron (15% B) at 1 ml/L (promod)
T_5	Spray Ca (7.5%) + B (2.5%) at 1 ml/L (calboro)

Flowering aspect measurements:

The number of panicles per tree was counted in April 2019, 2020, and 2021, during the full bloom stage. In order to determine the quantity of panicles and their length (in centimeters), ten panicles were extracted from each replicate.

Yield and physical characteristics:

Ten fruits were randomly selected from each replicate for the purpose of determining the physical and chemical parameters after the quantity of fruits on each tree was counted at harvest time. Fruit weight (g), dimension (cm), flesh %, and stone percentage are the physical attributes.

Chemical characteristics:

1- Fruit total soluble solids (TSS %) using hand Refractometer.

2- Reducing sugar and total (%).

3- Total acidity (%) as citric acid content and ascorbic acid (mg/100 ml juice were determined according to **[18]**.

Statistical analysis:

Tabulating and statistically analyzing all of the collected data for the tested treatments was followed the technique of **[19]**. L.S.D. at 5% was used to compare the individual comparisons between the parameters under study.

Results

1- Vegetative growth and leaf total chlorophylls:

The impact of spraying calcium, zinc, and boron on the shoot length, leaf area, and total chlorophyll of Keitt mango trees in 2019–2020 and 2021 is displayed in Tables (3 and 4). It is clear that across the three seasons under study, the results displayed a similar tendency. These findings suggest that, in comparison to spraying water (control), spraying any of the nutrients greatly enhanced these characteristics. Spray calcium with zinc produced the greatest values of these development parameters (T3). Conversely, the trees that received a water spray (control, T1) had the lowest levels of growth attributes. Due to sprays with water (T1), zinc (T2), calcium and zinc (T3), boron (T4), and calcium and boron (T5), respectively, the observed leaf area was 60.55, 70.65, 74.81, 66.64, and 71.87 cm2, and total chlorophyll was 33.15, 37.85, 40.03, 35.82, and 33.15 SPAD. Then, due to T2 to T4 compared to T1 (check treatment), the reached increment of the leaf area was 16.68, 23.55, 10.05, and 18.69%, and the total chlorophyll was attained at 14.18, 20.75, 8.05, and 16.61%, respectively. As a result, spraying mango trees with any kind of nutrients greatly boosted their vegetative development.

Table (3). Effect of calcium, boron and zinc spraying on shoot length and leaf number of Keitt mango trees during 2019, 2020 and 2021 seasons.

Treat.	Shoot length (cm)				Leaf number/shoot			
	2019	2020	2021	Mean	2019	2020	2021	Mean
T_1	9.30	9.60	9.65	**9.52**	10.76	11.73	13.30	**11.93**
T_2	11.60	11.10	12.11	**11.60**	12.43	14.31	16.25	**14.33**
T_3	12.17	11.86	12.68	**12.24**	14.62	15.40	17.36	**15.79**
T_4	10.42	10.34	10.84	**10.53**	12.00	13.18	14.94	**13.37**
T_5	11.13	11.18	11.58	**11.30**	13.67	14.62	16.59	**14.96**
LSD 5%	**0.48**	**0.55**	**0.52**	**0.31**	**0.57**	**0.66**	**0.74**	**0.41**

T_1: Control (water spraying), **T_2:** Spray with chelated zinc, **T_3:** Spray with InCa., **T_4:** Spray with boron, **T_5:** Spray with calboron.

Table (4). Effect of calcium, boron and zinc spraying on leaf area and total chlorophyll of Keitt mango trees during 2019, 2020 and 2021 seasons.

Treat.	Leaf area (cm^2)				Total chlorophyll (SPAD)			
	2019	2020	2021	Mean	2019	2020	2021	Mean
T_1	63.18	53.18	65.30	**60.55**	31.81	36.48	31.15	**33.15**
T_2	73.80	61.98	76.18	**70.65**	36.56	41.52	35.48	**37.85**
T_3	77.84	66.15	80.43	**74.81**	38.70	43.85	37.55	**40.03**
T_4	69.23	58.99	71.69	**66.64**	34.63	39.24	33.60	**35.82**
T_5	74.68	63.75	77.19	**71.87**	37.18	42.22	36.10	**38.50**
LSD 5%	**0.46**	**0.52**	**0.61**	**0.33**	**1.96**	**2.31**	**1.91**	**1.92**

2- Flowering performance:

The information in Table 5 illustrates how, over the course of the three seasons under study, various nutrition foliar sprays affected the flowering features of Keitt mango trees, specifically the length and number of panicles per tree. The application of various treatments resulted in notable changes in these flowering features, according to the data. In comparison to the control, spraying distinct nutrients greatly enhanced the number of panicles per tree and the length of the panicles.

Zinc (T2) sprays were applied after calcium (T3) sprays, which produced the highest values of these features. In comparison to the lowest values (59.80 & 42.05 cm as an average of three examined seasons) owing to spray water (control, T1), the maximum panicles/tree (73.63 & 70.40) and panicles length (54.15 & 51.72 cm as an average of three analyzed seasons) were caused by T3 and T2. Therefore, T3 and T2 in comparison to T1 were responsible for the increase in percentage of panicle length (28.78 and 22.44%) and panicle number obtained (23.13 and 17.73).

Table (5). Effect of calcium, boron and zinc spraying on flowering traits of Keitt mango trees during 2019, 2020 and 2021 seasons.

Treat.	Panicles number/tree				Panicle length (cm)			
	2019	2020	2021	Mean	2019	2020	2021	Mean
T_1	56.90	60.60	61.90	**59.80**	38.65	43.21	44.28	**42.05**
T_2	67.10	71.30	72.80	**70.40**	47.52	53.14	54.49	**51.72**
T_3	69.90	74.70	76.30	**73.63**	49.70	55.65	57.11	**54.15**
T_4	68.80	64.80	66.10	**66.57**	42.86	47.93	49.10	**46.63**
T_5	63.80	67.60	69.80	**67.07**	45.18	50.58	51.65	**49.14**
LSD 5%	**2.88**	**3.11**	**3.25**	**1.85**	**1.91**	**2.38**	**2.31**	**1.31**

3- Yield

Table (6) makes it evident that, in comparison to spray water (check treatment), spraying Keitt mango trees with zinc or boron in a single state or calcium with zinc or boron in a mixture greatly enhanced the quantity of fruit/tree and, consequently, yield/tree. The trees that received calcium plus zinc (T3), then zinc (T2), had the highest fruit/tree and yield/tree, while the ones receiving the comparison treatment (T1) had the lowest yield/tree. Because T1, T2, T3, T4, and T5 were used, the average yield/tree for the three investigated was 19.11, 28.13, 30.16, 22.93, and 25.18 kg/tree. Using T2, T3, T4, and T5 in comparison to T1 (control treatment) resulted in an increase in yield/tree of 47.20, 57.82, 19.99, and 31.76%, on average, over the course of three seasons. It follows that the benefits of spraying these nutrients on mango trees are evident.

Table (6). Effect of calcium, boron and zinc on fruit number and yield of Keitt mango trees during 2019, 2020 and 2021 seasons.

Treat.	Fruits/tree				Yield/tree (kg)			
	2019	2020	2021	Mean	2019	2020	2021	Mean
T_1	38.60	41.50	44.30	**41.47**	16.82	19.22	21.28	**19.11**
T_2	47.30	50.90	54.50	**50.90**	24.43	28.45	31.52	**28.13**
T_3	48.90	52.60	56.30	**52.60**	26.22	30.51	33.76	**30.16**
T_4	42.80	46.40	49.70	**46.30**	20.11	23.10	25.58	**22.93**
T_5	44.30	47.90	51.30	**47.83**	21.80	25.50	28.23	**25.18**
LSD 5%	**2.14**	**2.29**	**2.48**	**1.39**	**1.36**	**1.69**	**1.88**	**0.98**

4- Fruit Quality

Tables 7 to 9 clearly show that, in comparison to spray water (control), application of the varied nutrition greatly enhanced fruit quality in terms of boosting fruit weight, pulp%, T.S.S.%, and sugar contents, as well as vitamin C content and lowering overall acidity. The trees treated with calcium and zinc (T3) had the greatest values of fruit features, followed by zinc (T2) and calcium and boron (T5), in that order.

For the mango trees treated with T1, T2, T3, T4, and T5, the recorded fruit weight was 457.30, 551.03, 572.47, 500.00, and 524.43 g, respectively. The corresponding TSS values were 15.33%, 14.41, 15.13, 14.43, 15.05, and 15.41. Therefore, when comparing the T2 (check treatment) to the T3 (treatments T3, T4, and T5, the increment percentages of the fruit weight were achieved at 20.50, 25.18, 9.34, and 14.68%, respectively. Furthermore, the corresponding TSS increments were 7.08, 4.11, 6.38, and 4.99, respectively.

Table (7). Effect of calcium, boron and zinc on fruit weight and fruit pulp % of Keitt mangos during 2019, 2020 and 2021 seasons.

Treat.	Fruit weight (g)				Fruit pulp %			
	2019	2020	2021	Mean	2019	2020	2021	Mean
T_1	428.30	463.50	480.10	**457.30**	73.19	71.63	74.21	**73.01**
T_2	516.50	558.10	578.50	**551.03**	77.31	75.70	78.18	**77.06**
T_3	536.10	579.70	601.60	**572.47**	78.43	76.82	79.43	**78.23**
T_4	467.30	506.90	525.80	**500.00**	75.38	74.11	76.65	**75.38**
T_5	490.20	531.20	551.90	**524.43**	76.22	74.67	77.23	**76.04**
LSD 5%	**25.83**	**28.25**	**25.55**	**15.98**	**2.11**	**1.99**	**2.15**	**1.28**

Table (8). Effect of calcium, boron and zinc on TSS and sugar contents of Keitt mangos during 2019, 2020 and 2021 seasons.

Treat.	TSS (%)				Total sugars(%)				Reducing sugar(%)			
	2019	2020	2021	Mean	2019	2020	2021	Mean	2019	2020	2021	Mean
T_1	14.48	13.91	14.83	**14.41**	12.26	11.78	12.48	**12.17**	4.70	4.51	4.92	**4.71**
T_2	15.16	14.70	15.54	**15.13**	12.87	12.49	13.10	**12.82**	4.95	4.75	5.18	**4.96**
T_3	15.45	14.99	15.85	**15.43**	13.19	12.80	13.44	**13.14**	5.06	4.85	5.29	**5.07**
T_4	15.06	14.64	15.44	**15.05**	12.89	12.51	13.12	**12.84**	4.95	4.78	5.21	**4.98**
T_5	15.35	14.93	15.72	**15.33**	13.13	12.75	13.37	**13.08**	5.04	4.85	5.29	**5.06**
LSD 5%	**0.38**	**0.33**	**0.40**	**0.23**	**0.29**	**0.26**	**0.30**	**0.17**	**0.10**	**0.08**	**0.12**	**0.06**

Table (9). Effect of calcium, boron and zinc on V.C and acidity of Keitt mangos during 2019, 2020 and 2021 seasons.

Treat.	V.C. (mg/100 g)				Acidity			
	2019	2020	2021	Mean	2019	2020	2021	Mean
T_1	35.81	36.52	36.91	**36.41**	0.249	0.236	0.252	**0.25**
T_2	37.62	38.37	38.75	**38.25**	0.233	0.220	0.235	**0.23**
T_3	38.30	39.10	39.46	**38.95**	0.230	0.217	0.231	**0.23**
T_4	37.35	38.10	38.50	**37.98**	0.239	0.225	0.240	**0.23**
T_5	38.11	38.81	39.25	**38.72**	0.235	0.222	0.235	**0.23**
LSD5%	**1.18**	**1.23**	**1.33**	**0.76**	**0.010**	**0.009**	**0.010**	**0.007**

Discussion

Spray nutrients, such as calcium, zinc, and boron, may have an effective effect on growth and fruiting characteristics. Since calcium is necessary for cell elongation and division, it has a significant impact on how plants grow. The use of calcium may have increased growth parameters because of the mineral's function in both cell creation and the prevention of cellular degeneration **[20], [21], [22] and [23].** The obtained results were in agreement with **[24]** on Keitt and Ewais mango cultivars. The mango tree's shoot length, number of leaves per shoot, and leaf area all increased with varying ZnSO4 concentrations, indicating that Zn encouraged vegetative growth in terms of plant height, trunk girth, and plant spread **[25] and [26].**

Chlorophyll and this element's function in boosting photosynthesis and their part in increasing growth features may be the cause of these effects.

Furthermore, foliar spraying with B or Ca + B increased growth features in comparison to the control, according to our results. Boron spraying on Keitt mangoes may be advantageous because it can help synchronize the release of boron, prevent unintended nutrient losses to the soil, water, and air through direct plant internalization, and prevent nutrient interactions with water, soil, and airborne microorganisms, improving their efficiency and lowering soil toxicity **[27] and [28].** Further answers can be found in the significant regulatory effects of boron on sugar translocation and biosynthesis, metabolism enzyme activation, IAA synthesis, cell division and enlargement, water absorption, and nutrient transport **[29] and [30]**.

Zinc plays a crucial part in the manufacturing of the vital growth hormone auxin and is necessary for the synthesis of tryptophan, a precursor to IAA. It might also have to do with zinc's crucial function in a number of enzymes involved in energy transfer, protein synthesis, and plant metabolism **[31].**

Conclusion

These studies showed that, in comparison to the control, all of the investigated features increased and improved in response to the various foliar spraying treatments. The greatest yield with good fruit quality from Keitt mango trees would then result from applying 1 ml/L Ca^{+} Zn or Ca^{+} B at 1 ml/L twice.

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تأثير رش الكالسيوم والزنك والبورون علي نمو وإثمار أشجار المانجو (الكيت)

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الملخص

أجريت هذه الدراسة خلال مواسم 2019، 2020 ، 2021 بمزرعة خاصة في مركز دراو – محافظة أسوان – مصر. لدراسة تأثير رش الزنك أو البورون سواءً في حالة فردية أو خليط من الكالسيوم والزنك أو الكالسيوم والبورون علي النمو الخضري والمحصول وخصائص ثمار المانجو صنف الكيت . حيث تم استخدام أربعة معاملات من الزنك أو البورون أو خليط الكالسيوم مع الزنك أو البورون إضافه الي معاملة الكنترول التي تم رشها بالماء وقد صممت التجربه بنظام القطاعات كامله العشوائيه ذات ثلاثه مكررات وشجره واحده لكل منها.

وقد أظهرت النتائج ما يلي:

- أدي الرش بالعناصر المختلفه لزياده معنويه لكل من طول الفرع وعدد الاوراق ومساحه الورقه ومحتواها من الكلوروفيل مقارنة بمعاملة (الكنترول) التي تم رشها بالماء.
- أظهرت جميع معاملات الرش زيادة المحصول وتحسين خصائص الثمار من حيث زيادة وزن الثمرة ونسبة اللب وكذلك محتواها من المواد الصلبة الذائبة والسكريات وفيتامين (ج). مقارنة بالرش بالماء.
- ارتبطت زيادة النمو الخضري للأشجار وبالتالي المحصول وخصائص الثمار نتيجه الرش بمخلوط الكالسيوم والزنك يليه الرش بالزنك ثم رش خليط الكالسيوم والبورون.

من نتائج هذه الدراسة يمكن التوصية بأهميه رش مخلوط العناصر الغذائية مرتين خلال موسم النمو خاصه خليط الكالسيوم والزنك أو الزنك أو خليط الكالسيوم والبورون بمعدل 1 سم لكل لتر حيث يؤدي ذلك إلي تحسين النمو الخضري لأشجار المانجو الكيت مع إنتاج محصول عال ذو خصائص ثمرية جيدة.

الكلمات المفتاحية: كيت - إضافة ورقية - عناصر غذائية – جودة – محصول.