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(Original Article)

Effect of Some Treatments on Tolerance of Ewaise Mango Trees to Abiotic Stress

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Abstract

The roles of K, Ca, B, and biochar among other macro- and micronutrients are very important. Mango tree fruiting can be enhanced by applying a balanced dose of K, Ca, and B as well as using biochar as an organic fertilizer. In order to test the theory that applying these nutrients in combination would boost vegetative development and enhance the quality and productivity of Ewaise mango trees, a field investigation was carried out during three consecutive 2021, 2022 and 2023 seasons. Biochar and two sources of calcium, boron, and potassium (cal plus or zero salt). While Biochar was applied at a rate of 750 g/m2, all Ca, K, and B sources were applied at a rate of 12g or 60 ml/tree. The results showed that the shoot length, leaf area, leaf chlorophyll N, P, and K, yield, total soluble solids, and sugar levels were all markedly enhanced by these treatments. in addition, the results showed that salicylic acid, K, and B at zero salt were more effective than other treatments and controls. Furthermore, it was discovered that cal plus (Ca, K, and B) was more beneficial in improved the quality and yield, but zero salt was more effective in enhanced of the growth features. So, it is recommended that calcium or potassium should be administered in addition to boron or biochar to enhance the growth, yield, and quality of Ewaise mango trees and lessen the negative effects of abiotic stress.

Keywords: *Mango application, Nutrients, Quality, Yield*

Introduction

The mango ones of the most well-liked and well-known fruits in the world. 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 (Ministry of Agriculture, 2021).

Climate has a significant impact on the growth and fruiting of fruit trees. Cultivation and production of Mango productivity is beset with difficulties in tropical and subtropical regions of the world owing to shifting weather patterns (Gerbaud, 2012; Normand *et al*., 2013). Climate variables such as temperature, precipitation, light, humidity, and greenhouse gases can all have an impact on the mango phenological stage cycle (Christensen *et al*.,2007). Mango flowering may

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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 (Bhagwan *et al*.,2011). Better cultural techniques, such as the use of fertilizer compounds that contain some plant nutrients and antioxidants, can improve growth and fruiting. These nutrients, often referred to as macro- and micronutrients and antioxidants, are critical for the development of robust trees and an increase in tree yield. They are also in charge of enhancing fruiting and growth as well as enduring abiotic stress (El-Kosary *et al*., 2011 and El-Salhy *et al*., 2021). Improving nutrients 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 (Normand and Lauri, 2012). 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. Potassium (K) is involved in quality-related characteristics of fruit and is called a quality element (Ahmad *et al*., 2018). Numerous biochemical reactions that are necessary for cell physiological functions and enzyme activation depend on it (Anees *et al*., 2016). Farmers that grow mangoes typically apply potassium nitrate to induce flowering and increase yield. It makes plants more resilient to a variety of conditions, including high and low temperatures, drought, excessive watering, and salt stress (Dutta, 2011 and Eliwa, 2003).

One of the most crucial factors in determining the quality of fruit is calcium. Cell elongation and division depend on it (Rizzi and Abruzzese, 1990).

Because of the not calcium availability in the soil, there is 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 (Marschner, 2011).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 (Das, 2003).When calcium and zinc are applied together at a rate of 3.0 m/L, pollen germination and fruit set are positively impacted. It was effective to use K, Ca, and B to promote fruit set, fruit retention, and fruiting features. Even in situations when there is an abundance of boron (B), a number of illnesses are associated with B shortage, indicating that these disorders are physiological in character and have to do with B's mobility within plant tissues. Furthermore, fruit B concentrations are responsible for fruit setting and retention percentages. (Tohidloo and Souri, 2009).

Anaerobic biomass pyrolysis results in the stable carbon-based solid known as biochar. The ash content, row materials, and pyrolysis settings all affect the properties of biochar. As a promising soil supplement, it is improving the physicochemical characteristics of the soil, encouraging plant growth, increasing the amount of organic carbon in the soil, increasing its capacity to hold water, lessening the impacts of salt stress, and reducing soil pollution (Jeffery *et al*., 2011; Agegnehu *et al*., 2015 and Dahlawi *et al*., 2018).

Thus, the current study's goal was to investigate how biochar and some macro- and micronutrient applications effect on growth and fruiting of Ewaise mango trees. in addition, tolerance, and abiotic stress effects.

Materials and Methods

The current study was carried out over the course of three consecutive seasons in 2021, 2022, and 2023 In a private mango orchard located in Al-Qusia, Assiut governorate, where the soil is clay with a water table depth of at least two meters, The orchard soil analysis was performed in accordance with Wilde *et al.* (1985) and displayed in Table 1. Seven-year-old Ewaise mango trees that were planted seven by seven meters apart and budded on mango seedling rootstocks were chosen. Additionally, Table 2 displays average monthly air temperature and relative humidity data for the three seasons under study. A randomized complete block design (RCBD) was implemented. Table 3 provides specifics about the nutrition interventions. The following program was followed in order to carry out the treatments: On farms, fertilization was done as usual. At 750 g/m2, biochar was introduced in the middle of December. Furthermore, irrigation water at the necessary concentration was injected every 15 or 30 days for treatments 1 or 2, respectively, with cal plus or zero salt. Every mango tree was given the standard horticultural and agricultural treatments that were already used in the mango orchard, such as weed, disease, and insect management, watering with well water at a concentration of 1200 parts per million, pruning, and hoeing.

Generally, the following measurements were recorded during the three studied seasons.

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

Soil property	Value	Soil property	Value
Sand (%)	72.20	Total N (%)	0.09
Silt (%)	16.00	$NaHCO_3$-extractable P (mg/kg)	5.1
Clay (%)	11.80	NH_4AOC-extractable K (mg/kg)	115
Texture	Sand	EDTA-extractable micronutrients (mg/kg)	
pH (1:2.5 suspension)	8.11	Zn	1.31
EC (1:2.5 extract) (dS/cm)	4.22	Fe	2.1
O.M. (%)	0.9	Mn	2.2
$CaCO_3$ (%)	1.29	Cu	0.7

Table 2. Temperatures and relative humidity for Assiut governorate during 2021, 2022 and 2023 seasons

Year	2021						2022						2023					
Month	Temperature (°C)			Humidity (%)			Temperature (°C)			Humidity (%)			Temperature (°C)			Humidity (%)		
	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.
February	21.5	7.14	14.35	74.57	30.63	52.87	19.85	6.86	13.32	73.36	33.18	53.10	19.22	6.3	12.67	75.56	31.44	53.81
March	26.58	10.94	18.99	69.39	24.42	46.52	22.48	8.68	15.54	63.35	22.65	41.80	27.00	12.39	19.82	53.48	19.94	34.48
April	32.03	15.13	23.59	62.03	24.27	40.90	34.1	16.73	25.55	50.30	13.30	29.14	30.48	15.54	23.32	45.45	15.23	27.99
May	37.74	21.42	29.82	47.23	16.13	29.54	34.52	19.1	27.23	44.65	14.39	27.27	34.03	19.53	26.99	46.32	15.84	28.53
June	36.83	22.8	29.94	45.32	17.84	29.08	37.1	22.2	30.42	47.10	16.60	30.43	38.03	24.43	31.36	48.17	17.07	29.74
July	38.9	25.13	32.09	47.60	17.90	30.57	37.54	23.12	30.72	49.23	18.81	31.51	39.35	24.74	32.12	55.26	17.77	32.74
August	39.26	24.84	31.8	48.26	17.81	30.56	37.55	23.84	31.11	56.39	19.97	35.90	38.29	24.29	31.35	61.42	20.97	37.50

Source: After Assiut weather station

Growth aspect measurements

For every tree, ten secondary branches (1.5-cm-diameter) were tagged in February. Twenty new shoots in the growth flush were selected from the ten marked branches in order to determine the shoot length (cm), the number of leaves per shoot, and the leaf area (cm^2), using the following equation from Ahmed and Morsy (1999), L.A. is equal to leaf area (cm^2), and L and W are the maximum leaf length and width (cm), respectively. L.A. = 0.70 (L × W) – 1.06. The amounts of chlorophyll in leaves were also measured.

Measurements of leaf content of N, P and K and (as %)

At the end of September, ten tagged leaves were carefully plucked at random from each tree. Upon collection, the leaf samples were immediately wiped with a moist towel to eliminate any remaining material that could have an impact on the findings. Before being analyzed, the leaves were crushed, kept in little pockets, and oven-dried for 48 hours at 70 Co. As advised by 0.5 g of plant material was digested using hydrogen peroxide and sulfuric acid (Wilde *et al*., 1985).

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. The average fruit weight (g), average fruit length (cm), average fruit diameter (cm), average flesh percentage (%), average flesh weight (g), average peel weight (g), and average stone weight percentage (%)

Table 3. Details of the experimental nutrition treatments for the field application.

Treatments		Nutrition
T_1	Control	The recommended doses of fertilization (RDF)
T_2	Cal^{+}_{1}	RDF + Cal^{+} (9% Ca + 1% B + 10% K) 12 g/tree every 15 days
T3	Cal^{+}_{2}	RDF + Cal^{+} (9% Ca + 1% B + 10% K) 12 g/tree every 30 days
T4	Zero salt$_1$	RDF + zero salt (35% K (potassium humate) + 1% B + salicylic acid 60 g/tree every 15 days
T5	Zero salt$_2$	RDF + zero salt (35% K (potassium humate) + 1% B + salicylic acid 60 ml/tree every 30 days
T6	Biochar	Biochar at 750 g/m^2 during mid of December

Chemical characteristics

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

2-Total reducing sugars (%).

3-Total sugars (%).

4-Total acidity (%) as citric acid content according to (A.O.A.C., 2000).

5-V.C (mg/100 ml)

6-Fiber (%)

Statistical analysis

Following the protocol of all the collected data for the treatments under test were tabulated and statistically evaluated Snedecor and Cochran (1980). A new L.S.D. of 5% was used to compare the individual comparisons between the parameters that were evaluated.

Results

1- Vegetative growth as well as leaf total chlorophylls, N, P and K

The effects of macro- and micronutrients, biochar, and shoot length, leaf area, and total chlorophylls, as well as the N, P, and K contents of the leaves, are displayed in Tables from (4-6) for the 2021–2022–2023 growing seasons of Ewaise mango trees. It is clear from the data that the three seasons under study all displayed a similar tendency. According to these findings, utilizing biochar or other dietary supplement greatly enhanced these characteristics when compared to the untreated group (control). For 15 or 30 days (T2 and T3), the application of zero salt (potassium humate, boron, and salicylic acid) produced the highest values of these growth attributes. Biochar was then used (T6). Conversely, the trees that were left untreated (control, T1) had the lowest levels of the growth traits. As an average of the three studied seasons, the recorded leaf area was 78.10, 84.29, 84.93, 85.91, 86.42, and 82.64 cm2, total chlorophyll 47.84, 55.11, 55.47, 55.87, 56.54, and 52.15 SPAD, and N%, 0.99, 1.06, 1.07, 1.31, 1.32, and 1.15% as a result of applying with untreated one (control, T1), cal plus 1 (T2), cal plus 2 (T2), zero salt 1 (T4), zero salt 2 (T5), and biochar (T6), respectively. Then, owing to T2 to T6 compared to T1 (check treatment), the attained increment of the leaf area was 7.93, 8.75, 10.00, 10.65, and 5.81; total chlorophyll was 15.20, 15.95, 16.79, 18.18, and 9.10; and Leaf-N was 7.07, 8.08, 32.32, 33.33, and 16.17%, respectively. Furthermore, the findings showed that consuming Cal Plus or no salt for 15 or 30 days did not significantly alter anything. It is more cost-effective to use it once per thirty days. Therefore, the total leaf surface area, nutritional status, and vegetative development of mango trees were greatly boosted by adding any nutrition or biochar.

Table 4. Effect of nutrients and biochar application on shoot length and leaf area of Ewaise mango trees during 2021, 2022 and 2023 seasons

Treatment	Shoot length (cm)				Leaf area (cm^2)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
Control	11.79C	12.05C	12.18C	**12.01C**	78.53B	77.36B	78.41B	**78.10C**
Cal 1 (12 g) 15 days	12.93A	13.23A	13.34	**13.16**	84.8A	83.5A	84.58A	**84.29A**
Cal 1 (12 g) 30 days	13.10A	13.28A	13.39A	**13.26A**	85.43A	84.15A	85.22A	**84.93A**
Zero 1 (60 g/tree 15 days)	13.28A	13.54A	13.65A	**13.49A**	86.41A	85.11A	86.22A	**85.91A**
Zero 2 (60 g/tree 30 days)	13.19A	13.43A	13.56A	**13.39A**	87.0A	85.56A	86.71A	**86.42A**
Biochar 750 g/m^2	12.63B	12.89B	13.00B	**12.84B**	83.11A	81.89A	82.93A	**82.64B**
New L.S.D.	**0.55**	**0.61**	**0.60**	**0.34**	**4.53**	**4.36**	**4.48**	**2.59**

Same letters within column are not significantly different.

Table 5. Effect of nutrients and biochar application on total chlorophyll and leaf-N of Ewaise mango trees during 2021, 2022 and 2023 seasons

Treatment	Total chlorophyll (SPAD)				Leaf-N (%)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
Control	47.83C	48.36C	47.33C	**47.84C**	0.98D	0.94D	1.06D	**0.99D**
Cal 1 (12 g) 15 days	55.1A	55.68A	54.55A	**55.11A**	1.05C	1.01C	1.12C	**1.06C**
Cal 1 (12 g) 30 days	55.46A	56.05A	54.91A	**55.47A**	1.06C	1.02C	1.13C	**1.07C**
Zero 1 (60 g/tree 15 days)	55.86A	56.43A	55.33A	**55.87A**	1.31A	1.25A	1.37A	**1.31A**
Zero 2 (60 g/tree 30 days)	56.52A	57.1A	56.0A	**56.54A**	1.33A	1.24A	1.39A	**1.32A**
Biochar 750 g/m^2	52.1B	52.67B	51.68B	**52.15B**	1.14B	1.1B	1.22B	**1.15B**
New L.S.D.	2.73	2.54	2.39	**1.48**	0.04	0.04	0.05	**0.03**

Same letters within column are not significantly different.

Table 6. Effect of nutrients and biochar application on leaf-P and Kof Ewaise mango trees during 2021, 2022 and 2023 seasons

Treatment	Leaf-P (%)				Leaf-K (%)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
Control	0.218B	0.225B	0.229B	**0.224B**	0.63B	0.61B	0.65B	**0.63B**
Cal 1 (12 g) 15 days	0.236A	0.249A	0.253A	**0.246A**	0.74A	0.69A	0.72A	**0.72A**
Cal 1 (12 g) 30 days	0.243A	0.250A	0.255A	**0.249A**	0.75A	0.69A	0.71A	**0.72A**
Zero 1 (60 g/tree 15 days)	0.249A	0.257A	0.253A	**0.253**	0.76A	0.70A	0.73A	**0.73A**
Zero 2 (60 g/tree 30 days)	0.251A	0.260A	0.264A	**0.256A**	0.76A	0.70A	0.74A	**0.73A**
Biochar 750 g/m^2	0.238A	0.246A	0.251A	**0.245A**	0.75A	0.68A	0.71A	**0.71A**
New L.S.D.	0.018	0.023	0.021	**0.013**	0.03	0.04	0.06	**0.03**

Same letters within column are not significantly different.

3- Yield

Table 7 clearly shows that the application of biochar, macro- and micro nutrition, improved yield when compared to an untreated one (check treatment). The trees treated with 0% salt (T4 and T5) had the highest yield, followed by biochar (T6), and the comparison treatment (T6) had the lowest yield. Because T1, T2, T3, T4, T5, and T6 were used, the average yield/tree for the three investigated was 33.58, 38.16, 37.68, 40.72, 40.87, and 38.85 kg/tree. Using T2, T3, T4, T5, and T6 in comparison to T1 (check treatment) resulted in yield/tree increments of 13.64, 12.21, 21.26, 21.71, and 15.69% as averages over the course of three seasons. It follows that applying these fertilizers to mango trees has positive outcomes.

4- Fruit Quality

Tables 8 to 12 make clear that the application of the various nutrition significantly improved fruit quality when compared to the untreated control in terms of increasing fruit weight, pulp%, T.S.S.%, and sugar contents, as well as vitamin C content, and decreasing total acidity and total fiber%. The trees treated with zero salt had the highest values of fruit features, followed by cal plus, in that order.

For the trees treated with T1, T2, T3, T4, T5, and T6, the average fruit weight that was recorded was 165.89, 177.78, 179.12, 182.14, 183.76, and 173.86, and the pulp percentage was 75.78%, 71.76, 75.94, 76.29, 76.09, 76.45, and 75.78%, respectively. 16.25, 17.24, 17.12, 16.71, 16.83, and 16.95% were the corresponding TSS values. Therefore, by applying T2 and T6 treatments in comparison to T1 (check treatment), the increment percentages of the fruit weight were obtained at 7.17, 7.98, 9.80, 10.77, and 4.80%, and the pulp percentage attained at 5.82, 6.31, 6.03, 6.54, and 5.60%. Furthermore, the corresponding TSS average increments were 5.35, 2.83, 3.57, 4.31, and 6.09, respectively.

Due to the use of T1, T2, T3, T4, T5, and T6, respectively, the vitamin C content was also 42.51, 46.66, 46.41, 44.59, 44.75, and 45.21, and the total fiber was 1.04, 0.84, 0.82, 0.85, 0.84, and 0.83 in each of the three seasons under study. Therefore, the increase in V.C. as a result of T2, T3, T4, T5, and T6 relative to T1 was 9.76, 9.17, 4.89, 5.27, and 6.35, respectively. Conversely, under the untreated condition (T1), the proportion of total fiber degradation attributed to T2, T3, T4, T5, and T6 was 19.23, 21.15, 18.27, 19.23, and 20.19%, respectively.

Therefore, during the growth season, the most economical assessment of nutrition administration suggests utilizing zero salt (potassium humate, boron, and cyclic acid) every 30 days. A programme like this is crucial to enhancing the nutritional status and growth of trees, as well as to boost productivity and enhance fruit quality. Treatments also lessened the negative consequences of abiotic stress.

Table 7. Effect of nutrients and biochar application on yield and fruit weight of Ewaise mango trees during 2021, 2022 and 2023 seasons

Treatment	Yield (kg/tree)				Fruit weight (g)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
Control	30.73C	32.22C	37.80C	**33.58C**	165.74C	161.80C	170.13C	**165.89C**
Cal 1 (12 g) 15 days	35.57B	36.58B	42.34B	**38.16B**	177.59AB	173.51AB	182.25AB	**177.78B**
Cal 1 (12 g) 30 days	34.92B	36.39B	41.73B	**37.68B**	178.90AB	174.54AB	183.93AB	**179.12AB**
Zero 1 (60 g/tree 15 days)	38.90A	38.80A	44.47AB	**40.72A**	181.83AB	177.68A	186.90A	**182.14AB**
Zero 2 (60 g/tree 30 days)	38.11A	39.39A	45.20A	**40.87A**	183.41A	179.52A	188.35A	**183.76A**
Biochar 750 g/m^2	36.32B	37.33AB	42.89AB	**38.85B**	173.50B	169.65B	178.42B	**173.86B**
New L.S.D.	1.86	2.11	2.58	**1.27**	8.65	7.56	8.22	**4.72**

Same letters within column are not significantly different.

Table 8. Effect of nutrients and biochar application on fruit dimension of Ewaise mango trees during 2021, 2022 and 2023 seasons

Treatment	Fruit height (cm)				Fruit diameter (cm)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
Control	7.81B	7.58C	7.93C	**7.77D**	6.28C	6.15C	6.45C	**6.29D**
Cal 1 (12 g) 15 days	8.29A	8.03A	8.40A	**8.24B**	6.62B	6.48B	6.80B	**6.63B**
Cal 1 (12 g) 30 days	8.31A	8.01A	8.43A	**8.25B**	6.65AB	6.51AB	6.83AB	**6.66B**
Zero 1 (60 g/tree 15 days)	8.38A	8.06A	8.50A	**8.31A**	6.76AB	6.62AB	6.94AB	**6.77A**
Zero 2 (60 g/tree 30 days)	8.45A	8.13A	8.58A	**8.39A**	6.81A	6.67A	6.99A	**6.82A**
Biochar 750 g/m^2	8.02B	7.73B	8.14B	**7.96C**	6.46B	6.33B	6.65B	**6.48C**
New L.S.D.	0.20	0.15	0.20	**0.11**	0.17	0.16	0.18	**0.10**

Same letters within column are not significantly different.

Table 9. Effect of nutrients and biochar application on pulp and seed percentages of Ewaise mango trees during 2021, 2022 and 2023 seasons

Treatment	Pulp %				Seed %			
	2021	2022	2023	Mean	2021	2022	2023	Mean
Control	71.93B	71.25B	72.11B	**71.76B**	13.65A	14.60A	13.04A	**13.76A**
Cal 1 (12 g) 15 days	76.15A	75.38A	76.29A	**75.94A**	11.72C	12.61BC	11.18C	**11.84C**
Cal 1 (12 g) 30 days	76.53A	75.74A	76.61A	**76.29A**	11.42C	12.34C	10.95C	**11.57D**
Zero 1 (60 g/tree 15 days)	76.32A	75.54A	76.42A	**76.09A**	11.92BC	12.81B	11.43BC	**12.05B**
Zero 2 (60 g/tree 30 days)	76.65A	75.88A	76.81A	**76.45A**	11.72C	12.59BC	11.16C	**11.82C**
Biochar 750 g/m^2	75.64A	74.99A	75.72A	**75.78A**	12.13B	12.93B	11.65B	**12.24B**
New L.S.D.	3.11	2.89	3.25	**1.81**	0.38	0.35	0.28	**0.20**

Same letters within column are not significantly different.

Table 10. Effect of nutrients and biochar application on TSS and total sugars of Ewaise mango trees during 2021, 2022 and 2023 seasons

Treatment	TSS (%)				Total sugars (%)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
Control	16.78C	16.35C	15.72C	**16.25C**	12.38C	11.83C	11.18C	**11.80C**
Cal 1 (12 g) 15 days	17.75A	17.18A	16.79A	**17.24A**	13.15AB	12.56AB	11.70A	**12.47A**
Cal 1 (12 g) 30 days	17.66A	17.10A	16.60AB	**17.12AB**	13.19A	12.63A	11.73A	**12.52A**
Zero 1 (60 g/tree 15 days)	17.22B	16.71B	16.20B	**16.71B**	12.69B	12.15B	11.39B	**12.08B**
Zero 2 (60 g/tree 30 days)	17.39AB	16.80AB	16.29B	**16.83B**	12.77B	12.21B	11.39B	**12.12B**
Biochar 750 g/m^2	17.48AB	16.94AB	16.43AB	**16.95B**	12.86B	12.30B	11.46B	**12.21B**
New L.S.D.	0.43	0.39	0.41	**0.24**	0.29	0.31	0.20	**0.16**

Same letters within column are not significantly different.

Table 11. Effect of nutrients and biochar application on reducing sugar and total acidity of Ewaise mango trees during 2021, 2022 and 2023 seasons

Treatment	reducing sugar %				Total acidity (mg/100 ml)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
Control	4.61C	4.43C	4.31C	**4.45C**	0.338A	0.332A	0.324A	**0.331A**
Cal 1 (12 g) 15 days	4.85AB	4.65AB	4.52AB	**4.67AB**	0.281B	0.277B	0.266B	**0.275B**
Cal 1 (12 g) 30 days	4.91A	4.72A	4.54AB	**4.72A**	0.275B	0.271B	0.260B	**0.269B**
Zero 1 (60 g/tree 15 days)	4.72B	4.53B	4.42B	**4.57B**	0.285B	0.282B	0.271B	**0.280B**
Zero 2 (60 g/tree 30 days)	4.72B	4.55B	4.35B	**4.58B**	0.282B	0.278B	0.267B	**0.276B**
Biochar 750 g/m^2	4.78B	4.59B	4.45B	**4.61B**	0.280B	0.296B	0.265B	**0.280B**
New L.S.D.	0.10	0.09	0.09	**0.06**	0.023	0.026	0.020	**0.014**

Same letters within column are not significantly different.

Table 12 Effect of nutrients and biochar application on V.C and fiber % of Ewaise mango trees during 2021, 2022 and 2023 seasons

Treatment	V.C (mg/100 ml)				Fiber %			
	2021	2022	2023	Mean	2021	2022	2023	Mean
Control	43.48C	42.73C	41.43C	**42.51C**	1.05A	1.04A	1.02A	**1.04A**
Cal 1 (12 g) 15 days	47.63A	46.85A	45.49A	**46.66A**	0.85B	0.84B	0.83B	**0.84B**
Cal 1 (12 g) 30 days	47.34AB	46.63AB	45.25AB	**46.41A**	0.83B	0.82B	0.81B	**0.82B**
Zero 1 (60 g/tree 15 days)	45.49B	44.82B	43.45B	**44.59B**	0.86B	0.85B	0.84B	**0.85B**
Zero 2 (60 g/tree 30 days)	45.68B	44.96B	43.62AB	**44.75B**	0.85B	0.84B	0.83B	**0.84B**
Biochar 750 g/m^2	46.15AB	45.38B	44.10AB	**45.21B**	0.84B	0.83B	0.82B	**0.83B**
New L.S.D.	**1.72**	**1.45**	**1.89**	**0.98**	**0.07**	**0.08**	**0.12**	**0.05**

Same letters within column are not significantly different.

Discussion

With the addition of nutrients, such as K, Ca, and B, growth and fruiting qualities may be favorable. 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 (Merwad *et al*., 2016; Muengkaew *et al*., 2017; Bitange *et al*., 2019 Maklad *et al*., 2020). The obtained results were in agreement with El-Kosary *et al*. (2011) on the mango cultivars Keitt and Ewais. 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 (Singh and Rajput, 1977; Singh *et al*., 1987).

As the most common cation in plants, potassium is necessary for both respiration and the metabolism of carbohydrates. It also plays a key role in the preservation of the ionic balance within cells by binding ionically to the enzyme pyruvate kinase (Marschner, 1995).

Our findings also demonstrated that, in comparison to the control, the treatment of Ca and B plus K resulted in improved growth features. The advantages of applying boron to mango trees may stem from its ability to synchronize boron release, prevent unintended nutrient losses to the soil, water, and air through direct plant internalization, prevent nutrient interactions with water, soil, and airborne microorganisms, increase nutrient efficiency, and reduce soil toxicity (Rai, 2012 and Prasad *et al*., 2014).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(Nijjar, 1985 and Mengel *et al*., 2001). Meanwhile, molybdenum's vital function in the two main enzymes in plants nitrogenize and nitrate reductase that are necessary for nitrogen absorption accounts for its beneficial effects on the growth of mango Keitt cv. that was sprayed with the metal (Crane, 2019).

Also, it has synergistic effect on improving growth, flowering, yield and fruit quality of fruit crops (Samra *et al*., 2010; Ahmed *et al*., 2011; Ibrahim *et al*., 2013 and Fayek *et al*., 2014).

Potassium may improve photosynthetic synthesis and transport to fruit, which may be the reason for its beneficial effects on fruit. Additionally, because of the way that K interacts positively with other nutrients, particularly N, and with production methods, its impact on fruit quality may be indirect. Thus, adding potassium improved the mango's fruit quality (Ebeed *et al*., 2005; Stino *et al*., 2011 and Taha *et al*., 2014).

Our experiment's findings demonstrated that applying biochar to the soil is more important than applying each of the other for increasing fruit set %, shoot length, diameter, leaf area, and total chlorophyll. In addition, when compared to the control in the two seasons, they improved the fruit's physical and chemical properties as well as the mineral content of the leaves from macro- and micronutrients. The findings of earlier provided an explanation for these outcomes Van Vinh *et al*. (2015), Abo Ogiala (2018) and Khan *et al*. (2020) found that adding biochar greatly enhanced the fruit trees' growth performance as well as the fertility of the soil, including the soil's increased pH, cation exchange capacity, water-holding capacity, and root system architecture. It also reduced soil bulk density, increased yield, and enhanced fruit quality.

Conclusion

According to these findings, applying compounded fertilizers including calcium, potassium humate, boron, any antioxidants, and biochar improved and increased all of the features under study as compared to the control group. The best way to get the maximum yield and best fruit quality from Ewaise mango trees would then be to use biochar or apply 12g of cal plus (Cu, K, and B) or 60 ml of zero salt (K, B, and salicylic acid) to the tree every 30 days throughout the growth phase. It also lessened the negative consequences of abiotic stress.

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تأثير بعض المعاملات على تحمل أشجار المانجو العويس للإجهاد البيئي

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الملخص

أجريت هذه الدراسة خلال مواسم 2021، 2022، 2023 بمزرعة خاصة تقع في القوصية – محافظة أسيوط – مصر.

لدراسة تأثير استخدام بعض العناصر الغذائية والفحم النشط على النمو الخضري والحالة الغذائية والمحصول وخصائص ثمار المانجو العويس. حيث تم استخدام أربع معاملات من مخلوط العناصر الغذائية إضافة للفحم النشط ومعامله الشاهد. وقد صممت التجربة بنظام القطاعات كامله العشوائية ذات ثلاث مكررات وشجره واحده لكل منها.

وقد أظهرت النتائج ما يلي

سبب استخدام مخلوط العناصر أو الفحم النشط زيادة معنويه لكل من طول الفرع وعدد الاوراق ومساحه الورقة ومحتواها من الكلوروفيل والعناصر مقارنه بمعامله (الشاهد).

أدت جميع المعاملات المستخدمة إلي زيادة المحصول وتحسين خصائص الثمار من حيث زيادة وزن الثمرة ونسبة اللب وكذلك محتواها من المواد الصلبة الذائبة والسكريات وفيتامين (C). مقارنة بمعاملة الشاهد.

ارتبطت زيادة النمو الخضري والحالة الغذائية للأشجار وبالتالي المحصول وخصائص الثمار نتيجة إضافة مخلوط البوتاسيوم والبورون وحمض السالسيليك يليه الكالسيوم والبوتاسيوم والبورون أو الفحم النشط.

من نتائج هذه الدراسة يمكن التوصية بأهمية إضافة مخلوط العناصر الغذائية كل شهر خلال موسم النمو خاصه زيروسولت (بوتاسيوم، بورون وحمض السالسيليك بمعدل 60 مل/شجرة كل 30 يوم) حيث يؤدي ذلك إلي تحسين النمو الخضري والحالة الغذائية لأشجار المانجو مع إنتاج محصول عال ذو خصائص ثمريه جيدة إضافة إلى تقليل الآثار الضارة الناتجة عن الإجهاد البيئي.