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Effect of potassium, boron and fulvic acid spraying on fruting and tolerance of Zebda mango trees to abiotic stress

El Salhy, A.M.[1]; H.H.M. Saeed[2] and E.H. Salem[2] and M.E.S.Abdel-Hakm[2]
[1] Pomology Dept., Faculty of Agriculture, Assiut University
[2]Pomology Dept., Faculty of Agriculture and Natural Resources, Aswan University

Abstract

This study was conducted during three successive 2021, 2022 and 2023 seasons on a private farm in Al-Barahma – Qift district - Qena Governorate - Egypt. Aim the study to investigate the effect of potassium citrate, boron and fulvic acid on vegetative growth and fruiting of zebda mango. Seven treatments of potassium citrate, boron and fulvic acid were used in single, double or triple forms as the control treatment. The experiment was subjected to complete randomization block, with three replicates and one tree for each. The results showed the following:

Spraying potassium, boron and fulvic acid in single, double or triple forms caused a significant increase in shoot length, leaf area and chlorophyll content compared to the (control) treatment.

- All treatments used led to increased yield and improved fruit characteristics in terms of increased fruit weight and pulp percentage, as well as its content of soluble solids, sugars and vitamin C. compared to the control

An increase in the vegetative growth of trees and thus the yield and fruit characteristics was associated with the addition of a mixture of potassium, boron, and fulvic acid, followed by a mixture of potassium citrate and fulvic acid.

From the results of this study, we can recommend the importance of spraying potassium citrate, boron, and fulvic acid in its triple or binary form three times during the growing season, as this leads to improving the vegetative growth of mango trees while producing a high yield with good fruit characteristics, in addition to reducing the harmful effects resulting from environmental stress.

Corresponding author E-mail: e.mohamedbadawy@gmail.com

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Introduction

Mangoes is one of the most popular and favorite fruits in world. It has been considered the King of fruits and is widely cultivated in the tropical and subtropical regions. Mango cultivated areas in Egypt reached 326626 fed. with a total production about 1280310 tons **[1]** .

Climatic variables are seriously effects on fruit trees growth and fruiting. Tropic and sub-tropic areas of the world are facing many challenges regarding mango productivity. Due to changing climatic conditions **[2, 3, 4]**. Mango phenological stage cycle may get effected by a change in temperature, precipitation, light, humidity and greenhouse gases **[5]**. The anticipated climate changes and increasing CO_2 levels with global warming can result in greater changes in mango flowering and ultimately low yields of mangoes. The climate, especially high temperature during the flowering season induce erratic flowering in mango **[6]**. 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 **[7, 8]**.

To obtain higher yields, it is the necessity to improve nutrient supply and fertilizer use efficiency to minimize emissions of greenhouse gases. Due to high temperature in summers, mango gets vigorous vegetative growth and in winter early flowering issue becomes the reason for low yield **[3]**. Increasing nutrients application will increase mangoes yield but will not halt the decline in flowering or fruit drop, which is directly influenced by climatic factors. So, under changing climate, the management of natural resources like nutrients and water are a possible solution to the upcoming menace.

Potassium (K) is involved in quality-related characteristics of fruit and is called a quality element **[9]**.. It is crucial for many biochemical reactions that are essential for enzyme activation and physiological processes in cell **[10]**.To trigger flowering in mango potassium nitrate is being applied generally by mango growing farmers to enhance productivity. It increases the tolerance of plants for many stresses: drought, excessive water, salt stress, high and low-temperature stresses **[11, 12]**. As one of the most significant organic acids in the respiratory routes entering plant cells, potassium citrate is the potassium salt of citric acid **[13]**.

Fulvic acid increases the photosynthetic rate and reduces the opening of stomata and the transpiration rate to regulate plant growth as well as, enhances mineral element absorption **[14, 15]**.Besides, it improves the transfer of minerals directly inside the plant cells and chelates mineral nutrients **[16]**. Fulvic acid significantly increased leaf surface area, fruit number per tree, fruit weight, TSS% and total sugars **[17, 18]**.

Therefore, the objective of the current study was designed with to examine the effects of foliar application of potassium citrate, boron and fulvic acid on growth, yield and quality of Zebda mango trees.

Materials and Methods

The present study was conducted during the three consecutive seasons of 2021, 2022 and 2023 in a private mango orchard situated at Al-Brahma Qaft district, Qena governorate where the texture of the soil is clay with a water table depth not less than two meters. Twenty four -old Zebda mango trees budded on mango seedling rootstocks, and planted at 7x7 meters apart were selected for this study. Eight nutrition treatments were applied and executed in a randomized complete block design (RCBD) with three replications, one trees per each. Three foliar applications of potassium citrate, boron and potassium vulvate was applied for the three seasons in 1st March at the growth stage, first week of April at fruit setting stage, and after one month in the first week of May. The eight spray treatments as follow:

T1: spraying water (control)

T2: spraying 0.5% boron

T3: spraying 1% potassium citrate

T4: spraying 1% potassium vulvate

T5: spraying 0.5% boron plus 1% potassium citrate (double form)

T6: spraying 0.5% boron plus 1% potassium vulvate (double form)

T7: spraying 1% potassium citrate plus 1% potassium vulvate (double form)

T8: spraying 0.5% boron, 1% potassium citrate and 1% potassium vulvate (triple form)

All mango trees received the regular agricultural and horticultural practices, which were already followed in the mango orchard including pruning, hoeing, irrigation with Nile water as well as pests, pathogens, and weed control.

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

Growth aspect measurements:

Ten secondary branches with 1.5 cm diameter were labeled in February for each tree. From the ten labeled branches, twenty new shoots in the growth flush were chosen to measure shoot length (cm), the number of leaves/shoot and leaf area (cm^2) was measured according the following equation reported by **[19]**. L.A. = 0.70 (L x W) – 1.06 Where L.A. = leaf area (cm^2), L and W= maximum leaf length and width (cm), respectively. Also, leaf chlorophyll contents were measured.

Flowering aspect measurements:

At full bloom stage in April 2020 and 2021, number of panicles/tree was determined. Also, ten panicles were taken from each replicate to measure number of male flower/panicle, number of hermaphrodite/ panicle, sex ratio (%), and panicle length (cm).

Yield components:

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. At harvest, number of fruits per tree was counted

Fruit characteristics

At harvest, ten fruits were randomly taken from each replicate for determination the physical and chemical parameters. The physical characteristics namely average fruit weight (g), average fruit length (cm), average fruit diameter (cm), flesh percentage (%) and stone percentage (%). as well as Chemical characteristics

1- Fruit total soluble solids (TSS %) using hand Refractometer.
2- Total reducing sugars (%).
3- Total sugars (%).
4- Total acidity (%) as citric acid content according to **[20]**.

Statistical analysis:

All obtained data for the tested treatments were tabulated and statistically analyzed according to the procedure of **[21]**. The individual comparisons between the studied parameters were compared by using new L.S.D. at 5%.

Results

1- Vegetative growth and leaf total chlorophylls:

Table 1 show the effect of potassium citrate, boron and fulvic acid spraying on the shoot length, leaf area and total chlorophylls of zebda mango trees during 2021,2022 and 2023 seasons. It is obvious that the results showed a similar trend during the three studied seasons. Such results indicate that spraying of any potassium citrate, boron and fulvic acid significantly increased these traits compared to spray water (control). Moreover, no significant differences were seen due to use either double form as well as potassium citrate or fulvic acid.

The highest values of such growth traits were obtained due to spray potassium citrate, boron and fulvic acid in triple combination follow double form, boron and potassium citrate. On other hand, the lowest values of the growth traits were recorded for the trees that were sprayed with water (control). The recorded leaf area was (69.3, 76.1 ,78.1, 80.4, 84.4 , 80.6, 84.7 & 86.9 cm^2) and total chlorophyll (31.3, 39.3, 39.9, 38.4, 41.1, 40.6, 41.7, 41.7 & 42.3 SPAD as. av. of the three studied seasons) due to spray with water (T1), boron (T2), potassium citrate (T3), fulvic acid (T4), boron plus potassium citrate (T5), boron plus fulvic acid (T6), potassium citrate plus fulvic acid (T7) as well as potassium citrate and boron plus fulvic acid (T8), respectively. Then, the attained increment of the leaf area was (9.81, 12.99, 16.02, 21.79, 16.31, 22.22 & 25.54%) and total chlorophyll (25.23, 27.48, 22.68, 31.31, 29.71, 33.23 & 35.14% as av. of the two studied seasons) due to T2 to T8 compared to T1 (check treatment), respectively. Therefore, spraying with any treatment significantly increased the total leaf surface area, and vegetative growth of mango trees.

Table 1. Effect of Potassium citrate, boron and fulvic spraying on some growth traits of zebda mango trees in 2021, 2022 and 2023 seasons

Treatment	Shoot length(CM)				Leaf area (cm^2)				Total chlorophyll (SBAD/gf.w)			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
Control (T1)	25.2	29.1	26.9	27.1	66.1	72.5	69.2	69.3	32.3	30.5	31.1	31.3
boron (T2)	28.6	33.0	30.5	30.7	72.8	79.5	75.9	76.1	40.5	38.2	38.9	39.2
Potassium citrate (T3)	29.4	33.0	31.3	31.2	74.6	81.9	78.5	78.3	41.2	38.9	39.6	39.9
Fulvic (T4)	30.1	31.0	31.9	31.0	76.6	84.2	80.3	80.4	39.6	37.5	38.1	38.4
B/k (T5)	31.2	33.7	33.2	32.7	80.5	88.1	84.6	84.4	42.5	40.1	40.8	41.1
B/F (T6)	30.6	31.3	32.8	31.6	76.9	84.2	80.8	80.6	41.8	39.8	40.2	40.6
F/k (T7)	30.3	30.5	32.1	31.0	80.8	88.4	84.9	84.7	42.9	40.8	41.3	41.7
k/B/F (T8)	33.1	39.7	34.5	35.8	82.9	90.6	87.3	86.9	43.5	41.3	42.1	42.3
N.L.SD	2.28	2.49	2.21	1.35	5.68	5.84	6.11	3.41	1.68	1.53	2.15	1.04

2-Flowering performance:

Data in Table 2 show the effect of potassium citrate, boron and fulvic acid spraying on the Flowering traits, of zebda mango trees during 2021 , 2022 and 2023 seasons. It is obvious that the results showed a similar trend during the three studied seasons. The effect of different foliar application on flowering traits namely number of panicles/tree and sex ratio, data pointed out that there were significant differences in these flowering traits as result of implementation of different treatments. Spraying potassium citrate, boron and fulvic acid significantly increased number of panicles/tree and six ratios compared to control. Maximum values of these traits were recorded due to spray with Potassium citrate and boron plus fulvic acid (triple form, T8) followed spray with combination potassium citrate and fulvic acid (double form, T7). The highest panicles/tree (35.8 & 35.9) and sex ratio (73.7 & 73.3% as an av. of the three studied seasons) due to T8 and T7 compared the least values (27.3 & 68.5) due to spray water (control, T1). Hence, the increment percentage of panicle number attained (31.14 & 31.50) and sex ratio (7.59 & 7.01%) due to T8 and T7 compared to T1, respectively.

The recorded sex ratio was (68.5, 71.9, 72.9, 71.9, 72.8, 72.3, 73.3 & 73.7 as an av. of the two studied seasons) due to T1 to T8, respectively. Hence, the increment percentage of sex ratio (4.96, 6.42, 4.96, 6.24, 5.55, 7.01 & 7.59) due to T2 to T7 compared to T1, respectively.

From such results, it could be concluded that spraying with potassium citrate alone or combination with boron or at triple form increased panicle number and sex ratio of flowering mango trees.

Table 2: Effect of Potassium, boron and fulvic spraying on flowering traits of zebda mango trees in 2021,2022 and 2023 seasons.

Treatment	No. panicles				Six ratio(%)			
	2021	2022	2023	M	2021	2022	2023	M
Control (T1)	25.4	28.8	27.6	27.3	68.1	68.4	68.9	68.5
boron (T2)	32.2	35.6	34.4	34.1	71.3	71.8	72.6	71.9
Potassium citrate (T3)	32.8	36.5	35.3	34.9	72.1	72.9	73.8	72.9
Fulvic (T4)	31.5	35.1	33.6	33.4	70.9	72.1	72.6	71.9
B/k (T5)	33.3	36.8	35.7	35.3	72.2	72.9	73.4	72.8
B/F (T6)	32.4	36.3	34.8	34.5	71.8	72.3	72.8	72.3
F/k (T7)	33.8	37.6	36.3	35.9	72.8	73.5	73.6	73.3
k/B/F (T8)	33.6	38.1	35.8	35.8	73.3	73.8	73.9	73.7
N.L.SD	2.11	2.51	2.28	1.38	2.64	2.43	2.81	1.54

3-Yield components:

It is clear from Table (3) that the spraying of Zebda mango trees with the potassium citrate, boron or fulvic acid in singly, double or triple form significantly increased the fruit retention and yield/tree compared to spray water (check treatment). The maximum these yield components was recorded on the trees that were spray with triple form (T8), followed by double form T7, while minimum one was with the comparison treatment (control T1). The recorded yield/tree was (81.1, 95.7, 75.0, 93.5, 98.2, 96.9, 98.1 & 100.9 kg/tree as an av. of three studied due to use T1, T2, T3, T4, T5, T6, T7 and T8, respectively. The obtained increment of yield/tree as averages of two seasons was (18.0, 17.4, 15.29, 21.09, 19.48, 20.96 & 24.41% as a result of using T2, T3, T4, T5, T6, T7 and T8, compared to T1 (check treatment) respectively. Therefore, it is clear that the spraying of these treatments has beneficial effects on yielded mango trees.

Table 3: Effect of Potassium, boron and fulvic spraying on flowering traits of zebda mango trees in 2021,2022 and 2023 seasons.

Treatment	Fruit retention				Yield/tree			
	2021	2022	2023	M	2021	2022	2023	M
Control (T1)	2.41	2.57	2.52	2.5	75.9	84.5	82.8	81.1
boron (T2)	2.96	3.14	3.03	3.0	89.6	99.8	97.7	95.7
Potassium citrate (T3)	2.73	2.91	2.78	2.8	89.2	98.7	97.0	95.0
Fulvic (T4)	2.64	2.82	2.71	2.7	87.3	97.1	96.1	93.5
B/k (T5)	3.11	3.18	3.18	3.2	92.5	101.3	100.9	98.2
B/F (T6)	2.86	3.10	2.95	3.0	90.4	101.8	98.6	96.9
F/k (T7)	3.04	3.21	3.05	3.1	91.9	102.6	99.8	98.1
k/B/F (T8)	3.10	3.25	3.15	3.2	94.6	104.8	103.4	100.9
N.L.SD	0.19	0.22	0.16	0.12	7.28	8.67	8.31	4.77

4-Fruit Quality:

It is evident from Tables (4 to 7) that application of the different treatments significantly improved the fruit quality in terms of increasing the fruit weight, pulp %, T.S.S.% and sugar contents as well as, vitamin C content and decreasing the total acidity compared spray water one (control). The highest values of fruit traits were recorded on the trees that were sprayed with triple form T8 followed by double form (T5, T6 and T7), respectively. The recorded average fruit weight of mango was (353.2, 380.2, 390.0, 387.6, 389.5, 396.1, 397.8 & 400.1 g) for the trees that treated with T1, T2, T3, T4, T5, T6, T7 and T8, respectively. The respective TSS was (11.35, 12.5, 12.8, 12.4, 13.0, 12.9, 13.2 & 13.5%). Hence, the increment percentages of the fruit weight were attained

(7.64, 10.42, 9.74, 10.28, 12.15, 12.63 & 13.36%) due to using T2, T3, T4, T5, T6, T7 and T8 treatments, compared to T1 (check treatment) respectively. In addition, the respective average increment of TSS was attained (8.69, 11.3, 7.83, 13.04, 12.17, 14.78 & 17.39%), respectively.

With regard to acidity and V.C contents (table 8), all spraying treatments significantly reduced total acidity as compared with the control, and lower values in this respect were obtained by triple or double forms, respectively. Meanwhile, control treatment gave the highest value in this respect. On other hand, all spraying treatments significantly increased V.C contents as compared with the control,

The recorded V.C contents was (29.6, 31.7, 32.3, 31.3, 32.7, 32.9, 33.3 & 33.8as as an av. of the two studied seasons) due to T1 to T8, respectively.

Hence, the increment percentages of the V.C contents were attained (7.09, 9.12, 5.74, 10.47, 11.11, 12.5 & 14.19%) due to using T2, T3, T4, T5, T6, T7 and T8, compared to T1 (check treatment), respectively.

In general, the lowest percentage of fruit chemical properties except acidity were found in control. On the other hand, spraying triple form followed by double form recorded the highest value in this respect. No significant differences were found due to spray triple or double forms. So, in general economic view, it concluded that spray potassium citrate combined with boron or fulvic acid to get high yield with good fruits quality.

Table 4: Effect of Potassium, boron and fulvic spraying on Yield components of zebda mango trees in 2021, 2022 and 2023 seasons

Treatment	Fruit weight (g)				Pulp %				Seed (%)			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
Control (T1)	332.5	368.9	358.3	353.2	68.1	68.4	68.9	68.5	16.3	15.7	16.5	16.2
boron (T2)	358.4	396.1	386.1	380.2	71.3	71.8	72.6	71.9	15.1	14.4	15.3	14.9
Potassium citrate (T3)	368.5	404.6	396.8	390.0	72.1	72.9	73.8	72.9	14.9	14.2	15.0	14.7
Fulvic (T4)	365.1	403.0	394.6	387.6	71.9	72.1	72.8	72.3	14.8	14.3	15.1	14.7
B/k (T5)	365.8	408.2	394.4	389.5	72.5	72.9	73.4	72.9	15.0	14.3	15.2	14.8
B/F (T6)	373.6	410.4	404.3	396.1	71.8	72.3	72.8	72.3	15.1	14.4	15.0	14.8
F/k (T7)	371.8	411.2	410.4	397.8	72.8	73.5	73.6	73.3	14.7	14.0	14.8	14.5
k/B/F (T8)	376.4	416.1	408.6	400.4	73.3	73.8	73.9	73.7	14.6	13.8	14.7	14.4
N.L.SD	29.85	33.18	34.88	19.28	2.64	2.43	2.81	1.54	0.58	0.72	0.65	0.39

Table 5: Effect of Potassium, boron and fulvic spraying on fruit dimensions and seed% of zebda mango trees in 2021, 2022 and 2023 seasons.

Treatment	Fruit length(cm)				Fruit width (cm)			
	2021	2022	2023	M	2021	2022	2023	M
Control (T1)	12.5	13.2	13.0	12.9	9.1	9.6	9.4	9.4
boron (T2)	13.1	13.7	13.6	13.5	9.5	10.0	9.9	9.8
Potassium citrate (T3)	13.1	13.9	13.8	13.6	9.5	10.1	10.0	9.9
Fulvic (T4)	13.2	13.7	13.7	13.5	9.6	10.1	10.1	9.9
B/k (T5)	13.2	13.9	13.8	13.6	9.6	10.0	10.1	9.9
B/F (T6)	13.3	14.0	13.9	13.7	9.7	10.2	10.1	10.0
F/k (T7)	13.2	13.9	13.8	13.6	9.6	10.1	10.0	9.9
k/B/F (T8)	13.4	14.1	14.0	13.8	9.7	10.2	10.1	10.0
N.L.SD	0.49	0.46	0.52	0.29	0.32	0.29	0.38	0.19

Table 6: Effect of Potassium, boron and fulvic spraying on TSS and sugar contents of zebda mangoes in 2021, 2022 and 2023 seasons.

Treatment	TSS (%)				Total Sugar (%)				Reducing sugars			
	2021	2022	2023	M	2021	2022	2023	M	2021	2022	2023	M
Control (T1)	12.5	11.2	10.8	11.5	9.63	8.67	8.28	8.9	3.13	2.75	2.83	2.9
boron (T2)	13.6	12.1	11.8	12.5	10.74	9.36	9.10	9.7	3.45	3.10	3.11	3.2
Potassium citrate (T3)	13.8	12.4	12.1	12.8	10.63	9.58	9.16	9.8	3.47	3.12	3.15	3.2
Fulvic (T4)	13.5	11.8	11.8	12.4	10.39	9.30	8.94	9.5	3.38	2.97	3.06	3.1
B/k (T5)	14.1	12.7	12.3	13.0	10.88	9.79	9.36	10.0	3.55	3.12	3.18	3.3
B/F (T6)	13.9	12.5	12.2	12.9	10.71	9.64	9.22	9.9	3.48	3.10	3.12	3.2
F/k (T7)	14.3	12.9	12.4	13.2	11.10	10.10	9.55	10.3	3.61	3.22	3.25	3.4
k/B/F (T8)	14.6	13.2	12.7	13.5	11.25	10.13	9.68	10.4	3.68	3.28	3.32	3.4
N.L.SD	0.43	0.45	0.28	0.23	0.38	0.41	0.34	0.23	0.13	0.18	0.12	0.09

Table 7: Effect of Potassium, boron and fulvic spraying on acidity and V.C contents of zebda mangoes in 2021, 2022 and 2023 seasons.

Treatment	Acidity%				V.C (mg/100g)			
	2021	2022	2023	M	2021	2022	2023	M

Control (T1)	**0.61**	**0.68**	**0.71**	**0.67**	**31.5**	**29.3**	**28.1**	**29.6**
boron (T2)	**0.53**	**0.59**	**0.62**	**0.58**	**33.5**	**31.3**	**30.3**	**31.7**
Potassium citrate (T3)	**0.50**	**0.56**	**0.58**	**0.55**	**34.1**	**31.8**	**31.1**	**32.3**
Fulvic (T4)	**0.52**	**0.58**	**0.61**	**0.57**	**33.1**	**30.9**	**29.9**	**31.3**
B/k (T5)	**0.46**	**0.51**	**0.53**	**0.50**	**34.6**	**32.4**	**31.2**	**32.7**
B/F (T6)	**0.48**	**0.53**	**0.55**	**0.52**	**34.8**	**32.5**	**31.5**	**32.9**
F/k (T7)	**0.44**	**0.49**	**0.51**	**0.48**	**34.9**	**32.8**	**32.1**	**33.3**
k/B/F (T8)	**0.40**	**0.44**	**0.46**	**0.43**	**35.3**	**33.2**	**32.9**	**33.8**
N.L.SD	**0.036**	**0.044**	**0.049**	**0.046**	**1.43**	**1.29**	**1.33**	**0.81**

Discussion

With the addition of nutrients, such as K 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 **[22, 23, 24, 25]**. The obtained results were in agreement with **[7]**.

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 **[26]**.

Our findings also demonstrated that, in comparison to the control, the treatment of B and 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 **[27, 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, 30]**. 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 **[31]**.

Also, it has synergistic effect on improving growth, flowering, yield and fruit quality of fruit crops **[32, 33, 13, 34]**.

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 **[35, 36, 37]**.

Growth and fruiting characteristics could be effective due to spray nutrients, i.e. Potassium and boron. Potassium is the prevalent cation in the plant and playing a vital role in maintenance of ionic balance in the cell as well as it bounds ionically to the enzyme pyruvate kinase, which is the essential in respiration and carbohydrate metabolism **(Marschner, 1995) [26]** Moreover, citric acid chelating these free radicals and protecting plant from injury could result in prolonging shelf life of plant cells and enhancing growth characteristics **[38, 39]** These effects might be due to the role of chlorophyll and this element in enhancing photosynthesis and their role in improving growth traits. The positive effect of potassium citrate in this study might be related to the important role of citric acid. It is an antioxidant which has anti-stress effect leading to the protection of photosynthetic pigments and photosynthesis systems of the leaves **[40]**

Our results also pointed out that foliar spraying with potassium, boron and fulvic acid led to improve growth traits as compared to the control. The beneficial effects of spraying boron on the of Zebda mangoes might be due to its positive effect on the synchronizing release of boron and preventing undesirable nutrient losses to the soil, water and air via direct internalization by plants and avoiding the interaction between nutrients with the microorganisms of water, soil and air as well as improving their efficiency and decreasing soil toxic **[27, 28]** Moreover, the important regulatory effect of boron in biosynthesis and translocation of sugars, activating metabolism enzymes, building of IAA, cell enlargement and division, water absorption and nutrient transport give other explanations **[29, 30]**

The integration effect of citric acid as antioxidants with micronutrients especially Zn on fruit yield parameters were due the auxinic action and synergistic effect of antioxidants on flowering and fruiting of most fruit trees **[41]**

Also, it has synergistic effect on improving growth, flowering, yield and fruit quality of fruit crops **[32, 33, 13, 34]**

The positive effective of potassium in enhancing fruit might be due to its function in improving synthesis of photosynthates and their transport to fruit. Also, the effect of K on the fruit quality can be also indirect due to its positive interaction with other nutrients especially with N and production practices. So, potassium application enhanced fruit quality of mango **[35, 36, 42, 37]**

The results indicate that Fulvic acid positively impacts Zebda mango trees. It improves leaf area, total chlorophyll, fruit retention, yield and fruit quality. These findings are consistent with those of **[43]** 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 weight and diameter, and vitamin C content. In parallel to our findings, **[44]** 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 **[45, 46]**. As fulvic acid can enhance antioxidants, IAA, GA3 and Cytokines hormones and vitamins, it improves the vegetative growth in plants **[47]**

Conclusion

According to these findings, spraying potassium citrate,boron and fulvic asid improved and increased all of the features under study as compared to the control .The best way to get the maximum yield and best fruit quality from Zebda mango trees would then be to use, triple form or double form that recorded the highest value in this respect. No significant differences were found due to spray triple or double forms. So, in general economic view, it concluded that spray potassium citrate combined with boron or fulvic acid to get high yield with good fruits quality. It also lessened the negative consequences of abiotic stress.

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تأثير الرش بالبوتاسيوم والبورون وحمض الفولفيك علي إثمار وتحمل أشجار المانجو الزبدة للإجهاد البيئي

عبدالفتاح مصطفى الصالحى[1]، حسين حمدان سعيد[2]، النوبي حفني سالم[2]، محمد البدوي سعد عبدالحكم[3]

1- قسم الفاكهة – كلية الزراعة – جامعة أسيوط – أسيوط ، مصر

2- قسم البساتين – كلية الزراعة والموارد الطبيعية – جامعة أسوان، مصر

3-برنامج تكنولوجيا التصنيع الغذائى-كليه تكنولوجيا الصناعه والطاقه-جامعه طيبه التكنولوجية،مصر

الملخص

أجريت هذه الدراسة خلال مواسم 2021 ، 2022و 2023 بمزرعة خاصة تقع في البراهمه – مركز قفط-محافظة قنا – مصر. لدراسة تأثير رش سترات البوتاسيوم والبورون وحمض الفولفيك علي النمو الخضري والمحصول وخصائص ثمار المانجوالزبده. حيث تم استخدام سبعه معاملات من سترات البوتاسيوم والبورون وحمض الفولفيك في صوره فرديه او ثنائيه او ثلاثيه ومعامله الشاهد. وقد صممت التجربه بنظام القطاعات كامله العشوائيه ذات ثلاثه مكررات وشجره واحده لكل منها.

وقد أظهرت النتائج ما يلي:

- سبب رش البوتاسيوم والبوررن وحمض الفولفيك في صوره فرديه او ثنائيه او ثلاثيه زياده معنويه لكل من طول الفرع وعدد الاوراق ومساحه الورقه ومحتواها من الكلوروفيل 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 للأشجار وبالتالي المحصول وخصائص الثمار نتيجه إضافة مخلوط البوتاسيوم والبورون وحمض الفولفيك يليه مخلوط سترات البوناسيوم وحمض الفولفيك

من نتائج هذه الدراسة يمكن التوصية بأهميه رش سترات البوتاسيوم والبورون وحمض الفولفيك في صوره الثلاثيه او الثنائيه ثلاثه مرات خلال فصل النمو حيث يؤدي ذلك إلي تحسين النمو الخضري لأشجار المانجو مع إنتاج محصول عال ذو خصائص ثمرية جيدة إضافة إلي تقليل الآثار الضارة الناتجة عن الإجهاد البيئي.