ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Effect of Potassium, Zinc and Boron on Growth, Yield and Fruit Quality of Keitt Mango Trees.

***Baiea MHM[1], El-Badawy HEM[2], and El-Gioushy SF[3].**

[1]Horticultural Crops Technology Dept. National Research Center. Dokki. Giza. Egypt.(mh.baiea@nrc.sci.eg).
[2]Hort. Dept. Fac. of Agric. Benha Univ. Egypt. (hamed.albadawy@fagr.bu.edu.eg).
[3]Hort. Dept. Fac. of Agric. Benha Univ. Egypt.(sherif.elgioushy@fagr.bu.edu.eg).

ABSTRACT

The present investigation was carried out in two successive seasons of 2013 and 2014 on Keitt mango trees grown in sandy soil under drip irrigation system in National Research Centre, Researches and production Station, at El-Nobaria district, El-Behaira Governorate, Egypt. Trees were sprayed five times (one month intervals) with potassium nitrate at 0.0,1 and 2%, zinc sulfate at 200 ppm and boric acid at 200 ppm. Spraying started at March in the two seasons to study their effects upon growth, leaf mineral content, tree yield and fruit quality as well. Obtained results showed that, spraying Keitt mango trees five times with potassium nitrate at 2% combined with boric acid at 200ppm significantly increased number of branches/tree, branch diameter, number of leaves/branch, number of panicles/tree, number of retained fruits/tree, weight of fruit, fruit yield/tree and fruit quality parameters (i.e. TSS%, total sugars % and vitamin C), but it decreased fruit acidity. Whereas, using the low concentration of potassium nitrate (1%) combined with zinc sulfate at 200 ppm decreased the number of malformed panicles/trees. Moreover, using the combined treatment between potassium nitrate at 2% and zinc sulfate at 200 ppm improved shoot length (cm), leaf parameters)leaf area, fresh & dry weights and leaf chemical composition, as well.

Keywords: Keitt mango, potassium, zinc, boron, fruit quality and leaf mineral content.

****Corresponding author***

INTRODUCTION

Mango (*Mangifera indica* L.) is a very delicious tropical fruit belongs to family Anacardiaceae, it is also considered as the queen of the fruits as it is very popular world-wide. Mango fruit is an abundant source of vitamins, minerals and is famous for its excellent flavour, attractive fragrance and nutritional value. It is as an emerging tropical export crop and is produced in about 90 countries in the world with a production of over 820,877 MT [1]. In Egypt, mango is considered the most popular fruit. The area of mango orchards reached 241101 feddan, producing about 712537 tons of fruits annually [2]. Kiett mango cultivar grown successfully under the Egyptian conditions and its yield production comes in the late season.

The power of plant leaves to absorb nutrients has resulted in the fact that the foliar application of nutrients becomes a recurrent method for supplying nutrients to plants [3]. Foliar fertilization has the advantage of low application rates, uniform distribution of fertilizer materials and quick responses to applied nutrients. Moreover, hidden hungers can easily be managed [4].

Productivity of several mango cultivars was improved by potassium spray [5]. In this respect, the main role of potassium is the activation of many enzyme systems involved in the structure of organic substances and promotes photosynthesis and transport of the assimilates of the carbohydrates to the storage organs [6]. In addition, K is involved in several basic physiological functions. It resulted also in improving the fruit quality parameters, i.e., TSS%, total sugars and coloration [7]. These effects might be dedicated to the potassium role in increasing tolerance to stresses and improving the formation and accumulation rates of sugars [8, 9].

Boron and Zn deficiencies are more probable early in the season because the translocation of elements from the root to the aboveground portion may not be adequate before leaf expansion [10]. Zinc and B have a critical effect on flowering and fruit set and for this reason spring foliar application of these elements are frequently recommended in mango orchards.

Zinc and boron have promising effect on plant metabolism. They are responsible for producing the natural hormones IAA, activating some enzymes biosynthesis of chlorophylls, enhancing germination of pollens and regulating water uptake by plants [11].

Foliar application of nutrients, especially boron and zinc was essential for producing healthy mango trees as well as producing productive trees. In addition, they are responsible for improving physical and chemical parameters of fruits [12-15].

Zinc is a cofactor of over 300 enzymes and proteins and has an early and specific effect on cell division, nucleic acid metabolism, and protein synthesis [6]. It is an essential trace element for plants, being involved in many enzymatic reactions and is necessary for their good growth and development. Zinc is also involved in regulating the protein and carbohydrate metabolism [16]. Moreover, zinc uptake rate was faster in mango trees when zinc sulfate was foliar applied as compared with its soil application [15]. The positive effect of foliar application of zinc in increasing the productivity of mango was cited by [17, 18] and improving the fruit quality in terms of TSS and total sugars [19].

Boron has effect on many functions of the plant such as hormone movement, activate salt absorption, flowering and fruiting process and pollen germination specially its influences on the directionality of pollen tube growth, it seems to play an important role in achieving satisfactory fruit set [20,21]. Abdel-Fattah *et al.*, (2008) [22] on “Costate” persimmon found an increment in fruit weight due to foliar sprays of boric acid. Boron is involved in processes such as protein synthesis, transport of sugars and carbohydrate metabolism [23].

The main objective of this study was to investigate the effect of spraying mango trees with potassium nitrate, zinc sulfate and boric acid five times on growth, leaf mineral content, tree yield, and fruit quality.

MATERIALS AND METHODS

This study was carried out during two successive seasons (2013 and 2014) on five years old Keitt mango trees grafted on Succary seedlings as rootstocks and planted at 2×3 meters in sandy soil under drip irrigation system in National Research Centre, Researches and production Station at El- Nobaria district (El-Behaira Governorate). The selected trees were uniform in vigor, size and shape as possible as well as diseases free.

Potassium treatments

Keitt Mango trees received potassium nitrate (KNO_3) as foliar spray at 0.0, 1 and 2%.

Micronutrient treatments:

Keitt Mango trees were subjected to foliar spray with zinc sulfate at 200 ppm and boric acid at 200 ppm, beside water spraying as control treatment.

All applied treatments were sprayed five times at monthly intervals between different sprays, the first one was done at the first week of March in the two assigned seasons.

Layout of the experiment

The design of the experiment was factorial experiment in a complete randomize block design with 9 treatments represented the combination between potassium nitrate at the rate of 0, 1 and 2% and three micronutrients treatments i.e., 0.0 (as control), zinc sulfate at 200 ppm and boric acid at 200 ppm (3 potassium nitrate × 3 micro-nutrients treatments) replicated three times each replicate contains three trees.

Common agricultural practices (i.e., irrigation, manual weed control, fertilization, pest control, etc.) were carried out when needed as recommended in this region.

Studying parameters

Vegetative growth

At the end of October in the tow seasons, number of shoots, terminal shoot length (cm), shoot diameter (cm), leaf fresh and dry weight, leaf area (cm^2) and leaves number/shoots were recorded. The above mentioned growth aspects were investigated on the new formed shoots in the growth seasons.

Leaf mineral contents

Leaves sample were picked from the 3^{rd} and 4^{th} node below panicle at August 1^{st} of the two seasons. The samples were washed, dried, grounded and digested according to [24]. N, P, and K were determined in the digested solution as follows:

a) Total nitrogen was determined as percentage using the micro-Kjeldahl method as described by [25].
b) Phosphorus was estimated colorimetrically by the stannous chloride method as percentage according to [26].
c) Potassium content was determined by Flame photometer as percentage according to method of [27].
d) Total carbohydrates content was determined in dried leaf powder as percentage according to [28].
e) Micronutrients boron and zinc were measured using atomic absorption according to [29].
f) Total indoles and total phenols (mg/100 g fw) were determined in fresh leaves according to [30].

Flowering parameters

Number of total panicles/tree and number of malformed panicles/tree were recorded at full blooming stage (mid April).

Fruit yield

In each season, at harvest time (first of November), the numbers of fruits per tree and fruit yield per tree were counted for each treatment. All fruits were picked and weighted for each tree in different treatments, tree yield in kilograms was estimated by multiplying the number of fruits per tree and the average fruit weight.

Fruit quality

At harvest time, fruit samples of firm matured (commercial stage) were taken from each replicate to study the average of fruit total soluble solids content (TSS %) by hand refractometer, fruit acidity, vitamin C and total sugars were determined as described by [30].

Statistical analysis

Obtained data in the two studied seasons were subjected to the analysis of variance as factorial experiments in a complete randomize block design. Least significant differences (L.S.D.) were used to differentiate the obtained means at probability of 5% according to [31].

RESULTS AND DISCUSSION

A-Effect of potassium, Zinc and boron on vegetative growth measurements

1-Number of shoots/tree

Table (1) shows that the tow assigned potassium concentrations increased the number of shoots/tree to reach its maximum at the high concentration (2%) as compared with control in the two seasons. Moreover, all tested treatments of micro-nutrients significantly increased the number of shoots/tree, especially 200 ppm boric acid-sprayed trees as compared with unsprayed trees in the two seasons.

As for the interaction effect between potassium concentration and micro-nutrients, data in Table (1) reveal that all used combinations increased the number of shoots/tree with significant differences in most cases at the tow assigned seasons. However, the highest number of shoots/tree was recorded by the combined treatment between potassium nitrate at 2% and boric acid at 200ppm as it gave 45.30 and 59.70 shoots/tree in the first and second seasons, respectively.

2-Shoot length (cm)

Data in Table (1) indicate that the tested treatments exhibited statistically more pronounced effect in term of length of terminal shoots when compared with control in the two seasons. The trees sprayed with 200 ppm zinc sulfate or potassium nitrate at 2% treatments achieved the longest terminal shoot as compared with control trees in both seasons. However, foliar spraying of mango with 200 ppm zinc sulfate combined with potassium nitrate at 2% treatment is being the most effective one for inducing the longest terminal shoot as it gave 49.60 and 54.20 cm against the shortest shoot in control trees which produced 35.20 and 37.40 cm, in the first and second seasons, respectively.

ISSN: 0975-8585

Table 1: Effect of potassium, zinc and boron on number of shoots/tree, terminal shoot length and shoot diameter of mango cv. Keitt during 2013 and 2014 seasons.

Parameters	No. of Shoots /tree				Terminal shoot length (cm)				Shoot diameter (cm)			
First Season												
K conc. (A) / Micro-elements (B)	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean
control	32.1	35.4	39.7	**35.73**	35.2	43.6	41.8	**40.20**	0.72	0.89	0.93	**0.85**
Zinc sulfate 200 ppm	34.2	38.1	41.7	**38.00**	39.2	46.4	49.6	**45.07**	0.74	0.86	0.89	**0.83**
Boric acid 200 ppm	35.3	42.1	45.3	**40.90**	37.2	44.6	46.5	**42.77**	0.81	0.93	0.97	**0.90**
Mean	**33.87**	**38.53**	**42.23**		**37.2**	**44.87**	**45.97**		**0.76**	**0.89**	**0.93**	
L.S.D for (A) at 5%				**2.64**				**4.12**				**0.041**
L.S.D for (B) at 5%				**2.64**				**4.12**				**0.041**
L.S.D for (A×B) at 5%=				**4.41**				**6.88**				**0.068**
Second Season												
control	41.2	51.3	49.6	**47.37**	37.4	42.2	45.6	**41.73**	0.83	0.96	0.94	**0.91**
Zinc sulfate 200 ppm	46.3	53.2	56.4	**51.97**	45.3	52.1	54.2	**50.53**	0.81	0.92	0.94	**0.89**
Boric acid 200 ppm	48.5	55.1	59.7	**54.43**	41.8	49.3	48.2	**47.43**	0.89	0.96	1.14	**0.99**
Mean	**45.33**	**53.2**	**55.23**		**41.5**	**47.87**	**49.33**		**0.84**	**0.95**	**1.01**	
L.S.D for (A) at 5%=				**3.19**				**5.24**				**0.052**
L.S.D for (B) at 5%=				**3.19**				**5.24**				**0.052**
L.S.D for (A×B) at 5%=				**5.32**				**8.75**				**0.086**

3-Shoot diameter (cm)

Data in Table (1) clearly indicate that all studied treatments of micro-nutrients and potassium nitrate concentrations as well as their combination increased shoot diameter of mango trees as compared with water-sprayed trees in both seasons. However, the thicknest shoot of mango was noted by the combined treatment between 200ppm boric acid and potassium nitrate at 2% as it gave 0.97 and 1.14 cm, in the first and second seasons, respectively.

4-Leaf parameters

All examined treatments showed significant variations with respect to the number, area, fresh and dry weights of leaves (Table 2). However, both micro-nutrients succeeded in increasing the number of leaves /shoot with superior for boric acid in both seasons, whereas the highest values of leaf area, fresh and dry weights of leaf were scored by 200 ppm zinc sulfate in both seasons. Additionally, both concentrations of potassium statistically increased the number of leaves, fresh and dry weights of leaf with superior for potassium nitrate at 2% in both seasons. However, the highest number of leaves/shoot (35.3 and 39.5) was gained by the combined treatment between 200ppm boric acid and potassium nitrate at 2%, whereas the greatest leaf area (84.10 and 92.30 cm2), the heaviest leaf fresh weight (4.12 and 4.43 g) and leaf dry weight (0.86 and 0.92 g) were registered by the combined treatment between 200ppm zinc sulfate and potassium nitrate at 2%, in the first and second seasons, respectively.

Table 2: Effect of potassium, zinc and boron on fresh weight, dry weight, leaf area and number of leaves/shoot of mango cv. Keitt during 2013 and 2014 seasons.

Parameters	Leaf fresh weight (g)				Leaf dry weight (g)				Leaf area(cm^2)				No. of leaves/shoot			
First Season																
K conc. (A) / Micro-elements (B)	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean
Control	3.34	3.73	3.96	**3.68**	0.63	0.71	0.74	**0.69**	62.6	73.2	78.4	**71.40**	24.3	29.6	33.2	**29.03**
Zinc sulfate 200 ppm	3.52	3.84	4.12	**3.83**	0.70	0.79	0.86	**0.78**	69.4	77.3	84.1	**76.93**	26.4	31.7	32.9	**30.33**
Boric acid 200 ppm	3.46	3.74	3.93	**3.71**	0.68	0.78	0.82	**0.76**	66.4	73.7	78.4	**72.83**	28.7	33.6	35.3	**32.53**
Mean	**3.74**	**3.77**	**4.00**		**0.67**	**0.76**	**0.81**		**66.13**	**74.73**	**80.3**		**26.47**	**31.63**	**33.80**	
L.S.D for (A) at 5%	0.21				0.12				4.17				2.41			
L.S.D for (B) at 5%	0.21				0.12				4.17				2.41			
L.S.D for (A×B) at 5%=	0.36				0.2				6.96				4.02			
Second Season																
Control	3.56	3.93	4.17	**3.89**	0.66	0.75	0.81	**0.74**	69.4	79.7	83.2	**77.43**	26.4	32.1	35.1	**31.20**
Zinc sulfate 200 ppm	3.74	4.32	4.43	**4.16**	0.74	0.91	0.92	**0.86**	73.6	88.2	92.3	**84.70**	29.4	37.1	36.9	**34.47**
Boric acid 200 ppm	3.63	4.26	4.14	**4.01**	0.69	0.88	0.86	**0.81**	72.3	85.6	92.4	**80.10**	32.3	35.6	39.5	**35.80**
Mean	**3.64**	**4.17**	**4.25**		**0.70**	**0.85**	**0.86**		**71.77**	**84.50**	**85.97**		**29.37**	**34.93**	**37.17**	
L.S.D for (A) at 5%=	0.43				0.13				6.24				2.93			
L.S.D for (B) at 5%=	0.43				0.13				6.24				2.93			
L.S.D for (A×B) at 5%=	0.72				0.22				10.42				4.89			

The previous mentioned findings of vegetative traits could be interpreted on the basis of the physiological role of the nature of the used treatments action. Since, (as well be mentioned later, Table 5) the used treatments alter the endogenous levels of total indoles and total phenols that tended to increase the studied vegetative growth traits of mango trees. It is well established that indoles stimulate cell division and elongation and thus increasing vegetative growth parameters. The aforementioned results of potassium are in conformity with those reported by [32-34] on mango, [21] on date palm, [35] on barberry and [36] on Amhat date palm.

The abovementioned results of boron and zinc are in harmony with those attained by [37-41] on mango, [35] on barberry, [42] on costata persimmon trees, [43] on walnut and [44] on olive cv. Frontoio.

B-Effect of potassium, zinc and boron on leaf chemical composition measurements

It was obvious from Tables (3&4) that the two concentrations of potassium treatment increased leaf N, P, K, total carbohydrates, Zn and B contents as compared with control trees, with superior for the high concentration in both seasons of this study. Also, all tested application of micro-nutrients statistically increased leaf N, P, K, total carbohydrates, Zn and B contents, particularly 200ppm boric acid-sprayed trees, except for leaf Zn content as 200ppm zinc sulfate-sprayed trees showed its superiority in this concern.

Table 3: Effect of potassium, zinc and boron on N, P and K percentages of mango cv. Keitt leaf during 2013 and 2014 seasons.

Parameters	N (%)				P (%)				K (%)			
First Season												
K conc. (A) / Micro-elements (B)	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean
control	2.11	2.34	2.41	**2.29**	0.220	0.250	0.240	**0.237**	2.43	2.93	3.11	2.82
Zinc sulfate 200 ppm	2.29	2.73	2.68	**2.57**	0.230	0.260	0.270	**0.253**	2.56	3.08	3.26	2.97
Boric acid 200 ppm	2.32	2.81	2.92	**2.68**	0.240	0.270	0.280	**0.263**	2.74	3.28	3.30	3.11
Mean	**2.24**	**2.63**	**2.67**		**0.230**	**0.260**	**0.263**		**2.58**	**3.10**	**3.22**	
L.S.D for (A) at 5%	**0.31**				**0.021**				**0.19**			
L.S.D for (B) at 5%	**0.31**				**0.021**				**0.19**			
L.S.D for (A×B) at 5%=	**0.52**				**0.035**				**0.32**			
Second Season												
control	2.24	2.61	2.53	2.46	0.230	0.260	0.260	0.250	2.56	3.24	3.19	2.99
Zinc sulfate 200 ppm	2.36	2.59	2.64	2.53	0.240	0.270	0.260	0.257	2.73	3.86	3.82	3.47
Boric acid 200 ppm	2.39	2.69	2.79	2.62	0.260	0.270	0.290	0.273	2.91	3.41	3.48	3.27
Mean	**2.33**	**2.63**	**2.65**		**0.243**	**0.267**	**0.270**		**2.73**	**3.50**	**3.50**	
L.S.D for (A) at 5%=	**0.22**				**.023**				**0.21**			
L.S.D for (B) at 5%=	**0.22**				**0.23**				**0.21**			
L.S.D for (A×B) at 5%=	**0.37**				**0.038**				**0.35**			

Table 4: Effect of potassium, zinc and boron on total carbohydrate, zinc (ppm) and boron (ppm) content of mango cv. Keitt leaf during 2013 and 2014 sea

Parameters	Total carbohydrate (%)				Zn (ppm)				B (ppm)			
First Season												
K conc. (A) / Micro-elements (B)	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean
control	12.3	14.6	15.9	**14.27**	183.0	192.0	201.0	**192.0**	38.2	48.6	46.2	**44.33**
Zinc sulfate 200 ppm	12.4	16.3	17.4	**15.70**	212.0	216.0	226.0	**218.0**	41.2	46.1	47.9	**45.07**
Boric acid 200 ppm	14.9	18.3	19.2	**17.47**	193.0	208.0	214.0	**205.0**	46.2	49.2	52.3	**49.23**
Mean	**13.53**	**16.40**	**17.50**		**196.0**	**205.33**	**213.67**		**41.87**	**47.97**	**48.80**	
L.S.D for (A) at 5%	**2.34**				**16.21**				**4.19**			
L.S.D for (B) at 5%	**2.34**				**16.21**				**4.19**			
L.S.D for (A×B) at 5%=	**3.91**				**27.1**				**6.99**			
Second Season												
control	11.7	13.8	14.6	13.37	179.0	189.0	193.0	**187.00**	41.2	49.2	52.1	**47.50**
Zinc sulfate 200 ppm	13.1	15.7	15.4	14.73	204.0	211.0	223.0	**212.67**	43.4	48.1	47.4	**46.30**
Boric acid 200 ppm	15.2	17.6	18.1	16.97	186.0	209.0	204.0	**199.67**	46.2	54.6	58.0	**25.93**
Mean	**13.33**	**15.70**	**16.03**		**189.67**	**203.00**	**206.67**		**43.60**	**50.63**	**52.50**	
L.S.D for (A) at 5%=	**1.21**				**14.36**				**4.39**			
L.S.D for (B) at 5%=	**1.21**				**14.36**				**4.39**			
L.S.D for (A×B) at 5%=	**2.02**				**23.98**				**7.33**			

Regarding the interaction effect between micro-nutrients and potassium concentrations, data in Tables (3&4) reveal that all applied combinations increased all the tested chemical composition of mango leaves as compared with control trees in both seasons. However, using the treatment of 200ppm boric acid combined with potassium nitrate at the high rate is being the most effective one for inducing the greatest leaf N (2.92 and 2.79 %), P (0.280 and 0.290 %), total carbohydrates (19.20 and 18.10 %) and B (52.30 and 58.00 %) contents, whereas the highest values of leaf potassium (3.26 and 3.82 %) and Zn (226.0 and 223.0 %) contents were recorded by the combined treatments between 200ppm Zinc sulfate and potassium nitrate at the high level, in the first and second seasons, respectively.

In addition, data in Table (5) show that all tested applications of potassium nitrate and micronutrients as well as their combinations increased leaf total indoles content as compared with control in both seasons. However, the highest leaf total indoles content was scored by 200 ppm zinc sulfate-sprayed trees supported by spraying the trees with the high level of potassium nitrate in both seasons. On contrary, all studied potassium and micronutrients treatments as well as their interaction decreased leaf total phenols content as compared with control in both seasons, with superior for 200 ppm zinc sulfate-sprayed trees combined with 2% potassium nitrate sprayed trees.

Table 5: Effect of potassium, zinc and boron on total indoles and total phenols (mg/100g fw) of mango cv. Keitt leaf during 2013 and 2014 seasons.

The aforementioned results of potassium are in conformity with those reported by [32,33,34,40] on mango,[21] on date palm, [35] on barberry and [42] on costata persimmon trees.

Parameters	Total indoles (mg/100 g fw)				Total phenols (mg/100 g fw)			
First Season								
K conc. (A) / Micro-elements (B)	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean
control	218	226	239	**228**	162	154	151	**156**
Zinc sulfate 200 ppm	234	249	257	**247**	152	143	132	**142**
Boric acid 200 ppm	228	237	242	**236**	156	139	136	**144**
Mean	**227**	**237**	**246**		**157**	**145**	**140**	
L.S.D for (A) at 5%	**7.34**				**8.14**			
L.S.D for (B) at 5%	**7.34**				**8.14**			
L.S.D for (A×B) at 5%=	**12.18**				**13.51**			
Second Season								
control	227	243	251	**240**	174	168	163	**168**
Zinc sulfate 200 ppm	248	261	269	**259**	169	154	151	**158**
Boric acid 200 ppm	237	252	260	**250**	165	162	158	**162**
Mean	**237**	**252**	**260**		**169**	**161**	**157**	
L.S.D for (A) at 5%=	**8.36**				**5.11**			
L.S.D for (B) at 5%=	**8.36**				**5.11**			
L.S.D for (A×B) at 5%=	**13.87**				**8.48**			

The abovementioned results of boron and zinc are in harmony with those attained by [37,39,40] on mango, [35] on barberry, [45] on lemon (*Citrus aurantifolia* L.), [42] on costata persimmon trees, [43] on walnut and [46] on Peach.

C-Effect of potassium, Zinc and boron on flowering measurements

1-Number of panicles/tree

Data in Table (6) show that number of panicles/tree was significantly increased by using both micro-nutrient treatments with superiority for boric acid at 200ppm in both seasons. In addition, all tested concentrations of potassium nitrate increased the number of panicles/tree, especially the high concentration, with significant differences in both seasons. Concerning the interaction effect between micro-nutrients and potassium concentrations, data in the same Table reveal that all applied combinations increased the number of panicles/tree with significant differences as compared with un-treated trees in both seasons. However, the greatest number of panicles/tree was recorded by the combined treatment between 200ppm boric acid and potassium at the high rate as scored 41.70 and 51.60 panicles/tree, in the first and second seasons, respectively.

2-Number of malformed panicles/tree

Data in Table (6) clearly showed that all examined independent treatments of micro-nutrients and potassium concentrations as well as their combinations statistically decreased the number of malformed panicles/tree as compared with control in the two seasons. However, the lowest number of malformed panicles/tree was obtained by using 200ppm zinc sulfate and potassium at the low concentration as well as their combinations as compared either with the other treatments or control in the two seasons.

Table 6: Effect of potassium, zinc and boron on number of total panicles/tree and number of malformed panicles/tree of mango cv. Keitt during 2013 and 2014 seasons.

Parameters	No. of total panicles/tree				No. of malformed panicles/tree			
First Season								
K conc. (A) / Micro-elements (B)	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean
control	24.3	29.5	34.6	**29.47**	8.13	6.46	5.92	**6.84**
Zinc sulfate 200 ppm	29.7	33.9	36.4	**33.30**	5.84	4.91	4.21	**4.99**
Boric acid 200 ppm	30.5	37.6	41.7	**36.60**	7.43	5.80	5.31	**6.18**
Mean	**28.17**	**33.67**	**37.53**		**7.13**	**5.72**	**5.15**	
L.S.D for (A) at 5%	**3.14**				**1.17**			
L.S.D for (B) at 5%	**3.14**				**1.17**			
L.S.D for (A×B) at 5%=	**5.24**				**1.95**			
Second Season								
control	32.3	45.4	42.6	**40.10**	6.99	4.83	5.12	**5.65**
Zinc sulfate 200 ppm	39.4	46.7	48.3	**44.80**	4.23	3.62	3.01	**3.62**
Boric acid 200 ppm	41.8	49.3	51.6	**47.57**	5.26	4.71	4.15	**4.71**
Mean	**37.83**	**47.13**	**47.50**		**5.49**	**4.39**	**4.09**	
L.S.D for (A) at 5%=	**4.23**				**0.82**			
L.S.D for (B) at 5%=	**4.23**				**0.82**			
L.S.D for (A×B) at 5%=	**7.06**				**1.37**			

D-Effect of potassium, zinc and boron on yield measurements:

1-Number of fruits/tree.

Data in Table (7) cleared that all applied treatments of micro-nutrients and potassium concentrations as well as their combinations increased the number of fruits/tree with significant differences in most cases when compared with un-sprayed trees in the two seasons. In general, the highest number of fruits/tree was gained by 200 ppm boric acid-sprayed trees combined with potassium-sprayed trees at the high concentration as it gave 21.60 and 29.20 fruits/tree in the first and second seasons, respectively. Moreover, the combined treatment between 200 ppm boric acid and potassium sulfate at the low concentration, followed in descending order by 200ppm zinc sulfate-sprayed trees combined with potassium at the high concentration gave high significant increments in this concern.

2-Fruit yield/tree and fruit weight

Data in Table (7) clearly indicate that all treatments of micro-nutrients significantly increased fruits yield/tree and fruit weight, especially those sprayed with 200ppm boric acid as compared with control in the two seasons. In addition, fruits yield/tree and fruit weight were greatly increased by using both concentrations of potassium, especially the high one in the two seasons. However, all resulted interaction between micro-nutrients and potassium sulfate increased fruit yield/tree and fruit weight as compared with control in the two seasons. However, 200ppm boric acid-sprayed trees combined with potassium at the high level is being the most effective treatment for producing the greatest fruit yield/tree and fruit weight in the two seasons.

The aforementioned results of potassium are in conformity with those reported by [33,34,40] on mango and [35] on barberry.

The abovementioned results of boron and zinc are in harmony with those attained by [37,38,40,41] on mango, [42] on costata persimmon trees, [43] on walnut, [46] on Peach and [44] on olive cv. Frontoio.

Table 7: Effect of potassium, zinc and boron on number of fruits/tree, weight of fruits/tree and fruit yield/tree of mango cv. Keitt during 2013 and 2014 seasons.

Parameters	No. of fruits/tree				Fruit weight (gm)				Fruit yield/tree (kg)			
First Season												
K conc. (A) / Micro-elements (B)	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean
control	12.2	14.4	15.3	**13.97**	344.3	388.9	411.76	**381.64**	4.20	5.60	6.30	**5.37**
Zinc sulfate 200 ppm	14.7	17.6	19.5	**17.27**	381	415.3	428.72	**408.34**	5.60	7.31	8.36	**7.09**
Boric acid 200 ppm	17.8	20.3	21.6	**19.90**	401.1	411.8	437.96	**416.97**	7.14	8.36	9.46	**8.47**
Mean	**14.90**	**17.43**	**18.80**		**375.4**	**405.4**	**426.15**		**5.65**	**7.09**	**8.04**	
L.S.D for (A) at 5%				**2.14**				**18.34**				**1.14**
L.S.D for (B) at 5%				**2.14**				**18.34**				**1.14**
L.S.D for (A×B) at 5%=				**3.57**				**30.44**				**1.90**
Second Season												
control	16.4	23.6	21.2	**20.40**	368.3	418.6	435.38	**407.44**	6.04	9.88	9.23	**8.39**
Zinc sulfate 200 ppm	19.3	25.4	26.6	**23.77**	414	423.6	449.62	**429.08**	7.99	10.76	11.96	**10.23**
Boric acid 200 ppm	21.7	27.3	29.2	**26.07**	435	484.6	506.51	**475.38**	9.44	13.23	14.79	**12.49**
Mean	**19.13**	**25.43**	**25.67**		**405.8**	**442.3**	**463.84**		**7.82**	**11.29**	**11.99**	
L.S.D for (A) at 5%=				**3.29**				**16.18**				**1.38**
L.S.D for (B) at 5%=				**3.29**				**16.18**				**1.38**
L.S.D for (A×B) at 5%=				**5.49**				**26.86**				**2.30**

E-Effect of potassium, Zinc and boron on Fruit quality parameters:

Data in Table (8) realize that fruit T.S.S., total sugar and V.C. contents were greatly affected by using all treatments of micro-nutrients as compared with control, with superiority for 200ppm boric acid in both seasons. Also, potassium concentrations statistically increased fruit T.S.S., total sugars and V.C. contents, particularly the high concentration. Moreover, all resulted combinations between micro-nutrients and potassium concentrations improved fruit T.S.S., total sugars and V.C. content as compared with control in the two seasons.

However, the highest fruit TSS (19.40 and 19.20 %), total sugars (14.90 and 15.30 %) and V.C. (48.20 and 47.10 mg/100m F.W) contents were scored by the combined treatment between 200ppm boric acid and potassium nitrate at the high concentration in both seasons. Also, all tested treatments of micronutrients and potassium sulfate, as well be as their combinations reduced total fruit acidity (%), especially 200 ppm boric acid – sprayed trees supplemented with 2% potassium nitrate in the two seasons. Of interest, is to note that the abovementioned results when related with their flowering, fruiting and fruits quality aspects. Since, indoles are known as a stimulating hormone for longitudinal growth in different plants [47]. Hence, increments of endogenous total indoles level due to the use of treatments as well as the reduction of endogenous total phenols level (as well be mentioned ago) led to increase the most tested flowering, fruiting and fruit quality parameters.

Table 8: Effect of potassium, zinc and boron on total soluble solids (%), total sugars (%), vitamin C and acidity of mango cv. Keitt during 2013 and 2014 seasons.

Parameters	T.S.S (%)				Total sugar (%)				V.C. (mg/100m F.W)				Acidity (%)			
First Season																
K conc. (A) / Micro-elements (B)	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean	control	K (1%)	K (2%)	Mean
Control	14.5	16.2	15.9	15.53	11.2	13.4	12.8	12.47	38.6	42.3	46.7	42.53	0.73	0.69	0.64	0.69
Zinc sulfate 200 ppm	15.3	16.9	17.1	16.43	12.7	14.1	13.9	13.57	41.7	46.4	45.9	44.67	0.68	0.62	0.65	0.65
Boric acid 200 ppm	16.7	18.3	19.4	18.13	13.9	14.2	14.9	14.33	43.0	45.5	48.2	45.57	0.59	0.53	0.51	0.54
Mean	15.50	17.13	17.47		12.60	13.90	13.87		41.10	44.73	46.93		0.67	0.61	0.60	
L.S.D for (A) at 5%				2.17				1.39				2.03				0.023
L.S.D for (B) at 5%				2.17				1.39				2.03				0.023
L.S.D for (A×B) at 5%=				3.62				2.32				3.39				0.038
Second Season																
Control	13.9	16.8	17.2	15.97	10.7	12.6	13.1	12.13	36.4	45.9	48.6	43.63	0.68	0.54	0.59	0.60
Zinc sulfate 200 ppm	15.6	17.4	17.1	16.70	11.4	13.2	13.1	12.57	39.7	43.6	45.9	43.07	0.57	0.52	0.51	0.53
Boric acid 200 ppm	17.2	19.1	19.2	18.50	12.9	15.1	15.3	12.73	42.6	46.2	47.1	45.30	0.51	0.53	0.48	0.51
Mean	15.57	17.77	17.83		11.67	13.63	13.83		39.57	45.23	47.20		0.59	0.53	0.53	
L.S.D for (A) at 5%=				1.67				1.74				5.36				0.021
L.S.D for (B) at 5%=				1.67				1.74				5.36				0.021
L.S.D for (A×B) at 5%=				2.79				2.90				8.95				0.035

The aforementioned results of potassium are in conformity with those reported by [32,33,34,40] on mango.

Also, the abovementioned results of boron and zinc are in harmony with those attained by [37-41] on mango, [43] on walnut, [46] on peach and [44] on olive cv. Frontoio.

CONCLUSION

Generally, it could be concluded that spraying Keitt mango trees five times during the growing seasons with the combined treatments between 2% potassium nitrate and 200 ppm zinc or 200 ppm boron showed to be an economical recommendation for obtaining good vegetative growth, chemical composition and yield with fairly good quality.

REFERENCES

[1] Abbasi KS, Anjum N, Sammi S, Masud T and Ali S, Pak. J. Nutr., 2011; 10(2): 129-138.
[2] Ministry of Agriculture and Land Reclamation Statistics, Egypt 2013. Economic Affairs Sector. Bulletin of the Agricultural Statistics (In Arabic).
[3] Swietlik D and Faust M. Foliar nutrition of fruit crops. Hort. Rev. 1984; 6: 287-355.
[4] Umer, S., Bansal, S.K., Imas, P. and Magen, H., J. Plant. Nutr. 1999; 22: 1785-1795.
[5] Oosthuyes SA. South African Mongo Growers Association (Yearbook), 1993; 13:58-62.
[6] Marschner H. The Mineral Nutrition of Higher Plants. 1st Edn., Academic Press, NewYork, USA. 1986.
[7] El Seginy AM, Malaka SMN, El Messeih WMA and Eliwa GI. Alexandria Journal of Agricultural Research, 2003; 48(3): 137-143.
[8] Saleh MM and Abd El-Monem EA. Ann. Agric. Sci., 2003; 48: 747-756.
[9] Wahdan MT, Habib SE, Bassal MA and Qaoud EM. J. American Sci., 2011; 7(2). 651-658.
[10] Neilsen GH, Neilsen D, Hogue, E.J. and Herbert Can, L.C., J. Plant Sci. 2004; 84:823–828.
[11] Nijjar, G.S., Nutrition of Fruit Trees. Mrs. Usha. Raj Kumar Kalayan, New Delhi, 1985, pp 70-119.
[12] Banik, B.C., Sen, S.K. and Bose, T.K., Fazli. Environment and Ecology. 1997; 6(1), 122-125.
[13] Srihari, D. and Rao Karnataka, M.M., J. of Agric. Sci. 1998; 11(1), 257-259.
[14] Mohamed, A.Y. 1998; M.Sc. Thesis Fac. Agric. Minia Univ. Egypt.
[15] Bahadur, L., Malhi, C.S. and Singh, Z., J. Plant Nutrition. 1998; 21(3), 589-600.
[16] Swietlik, D., Zinc nutrition in horticultural crops. Horticultural Reviews. John Wiley & Sons, Inc. New York. 1999; 23, 109-180.
[17] Singh, G. and Maurya, A.N., Progressive Agriculture, 2004; 4: 47-50.
[18] Ranjit, K., Pawan, K. and Singh, U. P., Environ. Ecol., 2008; 26: 1965-1967.
[19] Rashmi, P. and Singh, C.P., Pantnagra J. Res., 2007; 5: 56-61.
[20] Baldi E, Toselli M, Deudellar D, Taglivini M and Maringoni B. Informatore-Agrorio, 2004; 60(21): 43-46
[21] Khayyat M, Tafazoli E, Eshghi S and Rajaee S. American-Eurasian Journal of Agricultural & Environmental Sciences, 2007; 2(3): 289-296.
[22] Abdel-Fattah DM, Mohamed SA and Ismail OM. Aust. J. of Basic and Applied Sci., 2008; 2(4): 1432-1437
[23] Hansch, R. and Mendel, R.R., Physiological of mineral micro-nutrients (Cu, Zn, Mn, Fe, Ni, Mo, B, Cl). Current opinion in plant Biol., 2009; 12: 259-266.
[24] Chapman, H. D. and Pratt, P. F., 1961. Methods of Analysis for Soil, Plant and Waters. University of California, Division of Agriculture Science.
[25] Pregl, E. 1945. Quantitaive Organic Micro Analysis 4th Ed. Chundril, London.
[26] Truog, E. and Meyer, A. H., Improvement in the denige's colorimetric method for phosphours and arsenic. Eng. Anal. Ed, 1929; 1: 481-488.
[27] Jackson, M. L. 1958. Soil Chemical Analysis, Prentice-Hall, Inc. Englewood Cliffs, New Jersey.
[28] Herbert D, Phipps PJ and Strange RE. Determination of total carbohydrates. Methods in Microbiology, 1971; 5(8): 290-344.
[29] Cottenie, A., Verloo, M., Velghe, G. and Comerlynk, R., 1982. Chemical Analysis of Plant and Soil. Ghent, Belgium, Laboratory of Analytical and Agro-chemistry State University.
[30] Association of Official Agricultural Chemists 1995; "Official Methods of Analysis". Pp. 490-510 14th Ed. Benjamin Franklin Station. Washington, D. C. U.S.A.
[31] Snedecor W and Cochran, WG. Statistical Methods, 8th ed. Iowa State Univ. Press Ames. Iowa. U.S.A. 1989.
[32] Astudillo EO and Bondad ND. Philippine Journal of Crop Science, 1978; 3 (3): 147-152.

[33] Nagao, M. A. and Nishina, M. S., 1993. Proceedings, Conference on Mango in Hawaii; March 9-11, Honolulu, Hawaii. Honolulu (HI): University of Hawaii. p. 61-66.

[34] Nahar, N., Choudhury, M. S. H. and Rahim, M.A., J. Agrofor. Environ. 2010; 4 (1): 31-34.

[35] Mehdi, K., Reza, M. A. M. Reza, K. A. and Soheila, R., Plants. Hort. Environ. Biotechnol. 2008; 49(5):1-5.

[36] Abd El-Migeed, M.M.M., Mostafa, E.A.M., Ashour, N.E., Hassan, H.S.A., Mohamed, Dorria M. and Saleh, M.M.S. International Journal of Agricultural Research, 2013; 8 (2): 77-86.

[37] Abd El-Razek, E., Abd-Allah, A.S.E. and Saleh, M.M.S., Middle-East Journal of Scientific Research, 2013; 14 (10): 1257-1262.

[38] Anees, M., Tahir, F.M., Shahzad, J. and Mahmood, N., Mycopath , 2011; 9(1): 25-28.

[39] Ibrahim HIM, Mohamed AY and Ahmed FF. African Crop Science Society, 2007; Vol. 8. pp. 411- 415

[40] Sarker, B. and Rahim, M. A., Bangladesh J. Agri. Res, 2012; *37(2): 279-293.*

[41] Singh, V.K., Bhriguvanshi, S.R. and Chatterjee, C., Asian J. Hort., 2009; 4(1):112-115.

[42] Kassem HA, et al.. J. Food Agric., 2010;22 (4): 259-274

[43] Keshavarz K, Vahdati K, Samar M, Azadegan B and Brown PH. Hort. Tech., 2011; 21(2):181-186.

[44] Jasrotia A, Bakshi P, Wali VK, Bhushan B and Bhat DJ. African Journal of Agricultural Research, 2014; 9(18):1354-1361.

[45] Rajaie, M., Ejraie, A.K., Owliaie, H.R. and Tavakoli, A.R., International J. Plant Prod., 2009; 3(1):39-50.

[46] Ali A, Perveen S, Noor S, Shah M, Zhang Z, Wahid F, Shah M, Bibi S and Majid A. American Journal of Plant Sciences, 2014; 5:1258-1264.

[47] Devlin M and Witham H. Plant physiology, 4th Ed. Publishers Willard, Grant press, Boston, 1983.