Fruiting of "Keitte" Mango Trees in Relation to Application of Glutathione and Boron

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Abstract: This study was conducted during 2014 and 2015 seasons to examine the effect of spraying boric acid and/or glutathione each at (0.05 up to 0.1%) three times at monthly intervals starting from the first March, on growth, tree nutritional status, yield and fruit quality of "Keitte" mango trees grown under sandy calcareous soil. An obvious promotion was revealed on all growth aspects, leaves pigments and nutrients content, fruit retention%, yield and fruit quality as affected by the tested treatments. Glutathione was appreciably superior to boric acid in this respect and using both together was preferable than using them individually. The promising treatment was the application of boric acid plus the antioxidant glutathione each at 0.1and 0.05%without significant differences among them. Therefore, from the economical point of view, it is advised to use this treatment at 0.05%, to obtain acceptable yield and fruit quality of "Keitte" mango trees grown under sandy calcareous soil.

Keywords: "Keitte" mango, glutathione, boron, yield, fruit quality

INTRODUCTION

Yield decline of "Keitte" mango trees grown under sandy saline and calcareous soil could be cured by using non-conventional practical methods such as using glutathione and boron that are famous for their promising effect on nutrition of different fruit crop species.

Glutathione as an important antioxidant is the most essential non-protein thiol present in the plants. It is essential in sulphur assimilation, nutrition and metabolism and defense against most biotic and abiotic stresses. It consists of three amino acids namely cysteine, glutamic and glycine. It is important pool of reduced sulphur and it regulates uptake of S. It is responsible for preventing the great damage caused by free radicals through react directly or indirectly with reactive oxygen species (ROS) and maintain the integrity of cell structure and the proper functions of various metabolic pathways. It is responsible for the expression of defense genes and involved in redox control of cell division. It is very potent in enhancing the biosynthesis of amino acids and proteins and it is associated with mechanisms of acclamation and adaptation (Rennenberg, 1982; Meister and Anderson, 1983; Jorge *et al*., 1993; Dekok and Stulen, 1993; Noctor and Foyer, 1998; Kocsy *et al*., 2001; Mengel *et al*., 2011; Grill *et al*., 2001).

Foyer and Lelandias (1993), Mullelineaux and Rausch (2005), Khattab (2007) and Szala *et al*. (2008) emphasized the beneficial of glutathione on enhancing the tolerance of plants to all stresses.

Boron is essential micronutrients for all fruit crop species development. It is very important for all reproductive tissues. During flowering and fruit setting, boron deficiency can result in dropping of flowers and poor fruit setting, since it plays a main role in early seasons shoot growth; pollen growth and tube germination, since it is needed for fertilization process and fruit setting (Mengel *et al*., 2001; Peacock and Christensen, 2005; Marschner, 2012).

For all the previous great functions of both the antioxidant glutathione and boron the idea of using both on promoting the productions of "Keitte" mango trees was bursted.

Previous studies showed that using glutathione (Mahgoub-Mona *et al*., 2006; El-Khawaga *et al.,* 2007; Mohamed, 2012; Abdelaal *et al*., 2012; Gad El-Kareem, 2012; Ahmed *et al*., 2012; Al-Qubaie, 2012; El-Khawaga and Mansour, 2014; Gaber, 2016) and boron (Abo El-Komsan *et al*., 2003; Abd-Allah, 2006; El-Sayed-Esraa, 2007; Ebeid-Sanaa, 2007; Desouky *et al*., 2007; Abdalla, 2008; Ahmed *et al.,* 2009; Harhash and Abdel-Nasser, 2010; Gamal, 2013; Hassan-Huda, 2014; Ibrahim and Al-Wasfy, 2014; Mahmoud, 2015; Abd El-Wahab, 2015; Mohamed *et al*., 2015; Abdelbaky, 2015; Mostafa, 2015; Habasy-Randa *et al*., 2016; Mahmoud, 2016) was very effective in improving yield and fruit quality in different horticultural crop species.

The target of this study was to examining the effect of spraying glutathione and/or boron on growth, yield and fruit quality of "Keitte" mango trees.

MATERIALS AND METHODS

This experiment was conducted during 2014 and 2015 seasons on 30 "Keitte" mango cv. trees onto Succary mango rootstock, grown in sandy calcareous soil in a private mango orchard situated at Delengat district, Beheara Governorate, Egypt. The selected trees were 7-years old, healthy, nearly uniform in vigour, planted at 2 (between trees) x3 (between rows) meters apart and received the same horticultural practices that already applied in the orchard. Drip irrigation system using well saline irrigation water containing 350 ppm saline was used. Soil analysis was done according to the procedure that outlined by Chapman and Pratt, (1965) and the data are shown in Table (1).

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Table (1): Analysis of the tested soil

Content	Value
Sand %	78.2
Silt %	6.8
Clay%	15.0
Texture	Sandy
O.M. %	0.52
pH (1: 2.5 extract)	8.0
EC (1: 2.5 extract) dsm^{-1})	1.0
Calcium carbonate %	7.1
Total N%	0.03
Available P (Olsen, ppm)	1.8
Available K (ammonium acetate, ppm)	32.9
EDTA extractable micronutrients (ppm)	
Zn	0.6
Fe	0.9
Mn	1.0

This experiment included the following ten treatments:

1. Control (sprayed with water).
2. Spraying boric acid at 0.025% (0.25 g/L).
3. Spraying boric acid at 0.05% (0.5 g/L).
4. Spraying boric acid at 0.1% (1.0 g/L).
5. Spraying glutathione at 0.025% (0.25 g/L).
6. Spraying glutathione at 0.05% (0.5 g/L).
7. Spraying glutathione at 0.1% (1.0 g/L).
8. Spraying boric acid and glutathione each at 0.025%.
9. Spraying boric acid and glutathione each at 0.05%.
10. Spraying boric acid and glutathione each at 0.1%.

Each treatment was replicated three times, one tree per each. Therefore, for carrying out this study, thirty uniforms in vigor "Keitte" mango trees were selected. Boric acid (17% B) and the antioxidant glutathione were sprayed three times at the first week of March, April and May during both seasons. Triton B as a wetting agent was added to all solutions at 0.05% and spraying was done till runoff (10-20 L/tree according to the date of spraying). Randomized complete block design (RCBD) was followed.

During both seasons, the following parameters were measured, main shoot length (cm.) and leaf area (cm)^{2}of non-fruiting shoots (5 - 6 months old) (Ahmed and Morsy, 1999); leaf pigments namely chlorophylls a and b, total chlorophylls and total carotenoids mg/100gF.W; (von-Wettstine, 1957); of Npercentages, P, K, Mg, Ca and S (on dry weight basis) in the leaves taken from non-fruiting shoots of (5-6 months old) (Summer, 1985 and Carter, 1993); fruit retention %; yield expressed in weight (kg.) and number of fruits/tree. In addition, physical and chemical characteristics of fruits were estimated. weight (g.), height, diameter and thickness (cm), percentages of seeds, peels and pulp of the fruit, edible (pulp) to non-edible (seeds and peels) portions of the fruit, percentages of T.S.S., total acidity as g citric acid/100g pulp, total and reducing sugars, vitamin C content (mg/100 g pulp) and total fibre % (A.O.A.C, 2000) were evaluated.

Statistical analysis was done according to Snedecor and Cochman (1980) and New L.S.D. test at 5% was used to differentiate among the various treatment means.

RESULTS

Growth aspects

Data in Table (2) revealed that single and combined applications of both boric acid and glutathione each at 0.025 up to 0.1% had significant stimulation on shoot length and leaf area of "Keitte" mango trees relative to the control treatment. The promotion was related to the increase in concentrations of both boric acid and glutathione. Combined applications were significantly superior than using each material alone in enhancing such two growth parameters. Application of glutathione significantly stimulated such two growth traits compared to using boric acid. The maximum values were recorded on the trees that received three sprays of boric acid plus glutathione each at 0.10% without significant differences with those sprayed by the same combination at 0.05%.The untreated trees produced the lowest values. These results were true during both seasons.

Leaf chemical components

Data in Tables (2 and 3) clearly show that trees sprayed with boric acid and/or glutathione each at 0.025 up to 0.1% was significantly enhanced chlorophyll a, b, total chlorophylls and total carotenoids. Moreover, it was increased leaves mineral content i.e., (N, P, K, Mg, Ca and S) as compared with control. There was a gradual promotion on leaf pigments and nutrients with increasing concentrations of both materials. Using glutathione was significantly superior to using boric acid in this respect. Combined applications were significantly effective on this respect than using each material alone. Three sprays of a mixture of boric acid and glutathione each at 0.1% were responsible for maximizing these plant pigments and nutrients without significant differences with those sprayed by the same combination at 0.05%. The lowest values were recorded on the untreated trees. These results were true during 2014 and 2015 seasons.

Table (2): Effect of spraying boric acid and/or glutathione on shoot length, leaf area and leaf pigments of the spring growth cycle of "Keitte" mango trees during 2014 and 2015 seasons

Treatment	Shoot length (cm)		Leaf area $(cm)^2$		Chlorophyll a (mg/100g F.W)		Chlorophyll b (mg/100g F.W)		Total chlorophylls (mg/100g F.W)		Total carotenoids (mg/100g F.W)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control (sprayed with water)	38.5	39.9	69.1	70.3	1.41	1.41	0.41	0.44	1.82	1.85	0.39	0.36
Boric acid at 0.025%	40.1	41.9	70.6	71.3	1.72	1.74	0.51	0.52	2.23	2.26	0.47	0.43
Boric acid at 0.05%	41.9	45.0	71.9	72.5	2.09	2.29	0.61	0.60	2.60	2.89	0.55	0.50
Boric acid at 0.1%	42.0	45.3	72.0	72.7	2.19	2.32	0.62	0.61	2.75	2.93	0.56	0.51
Glutathione at 0.025%	43.9	46.5	73.9	74.0	2.40	2.67	0.71	0.70	3.11	3.37	0.64	0.57
Glutathione at 0.05%	46.0	47.9	76.0	74.9	2.71	3.06	0.82	0.78	3.53	3.84	0.70	0.64
Glutathione at 0.1%	46.3	48.0	76.7	75.0	2.81	3.12	0.83	0.79	3.64	3.91	0.71	0.66
Both at 0.025%	48.0	49.2	79.0	76.0	3.19	3.57	0.90	0.89	4.09	4.46	0.80	0.75
Both at 0.05%	50.6	50.5	80.3	78.9	3.40	3.73	0.97	0.96	4.37	4.71	0.87	0.82
Both at 0.1%	51.0	50.6	80.7	79.0	3.51	3.83	0.98	0.97	4.49	4.80	0.88	0.83
New L.S.D at 5%	**1.3**	**1.2**	**1.0**	**0.9**	**0.14**	**0.15**	**0.07**	**0.08**	**0.14**	**0.15**	**0.07**	**0.06**

Table (3): Effect of spraying boric acid and/or glutathione on leaves mineral content of "Keitte" mango trees during 2014 and 2015 seasons

Treatment	Leaf N %		Leaf P %		Leaf K %		Leaf Mg %		Leaf Ca %		Leaf S %	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control (trees sprayed with water)	1.15	1.23	0.04	0.04	0.99	1.00	0.47	0.50	1.33	1.29	0.06	0.05
Boric acid at 0.025%	1.23	1.29	0.07	0.08	1.05	1.06	0.51	0.53	1.44	1.40	0.10	0.09
Boric acid at 0.05%	1.30	1.36	0.12	0.11	1.11	1.11	0.55	0.57	1.55	1.51	0.14	0.14
Boric acid at 0.1%	1.31	1.37	0.13	0.12	1.12	1.12	0.56	0.58	1.57	1.52	0.15	0.15
Glutathione at 0.025%	1.40	1.44	0.16	0.15	1.20	1.17	0.62	0.64	1.70	1.66	0.18	0.18
Glutathione at 0.05%	1.49	1.50	0.20	0.18	1.29	1.23	0.69	0.67	1.80	1.77	0.21	0.22
Glutathione at 0.1%	1.50	1.50	0.21	0.19	1.30	1.24	0.70	0.68	1.81	1.78	0.22	0.23
Both at 0.025%	1.59	1.55	0.24	0.22	1.40	1.33	0.74	0.72	1.94	1.89	0.26	0.27
Both at 0.05%	1.69	1.61	0.27	0.25	1.46	1.40	0.78	0.75	2.04	2.01	0.29	0.31
Both at 0.1%	1.70	1.62	0.28	0.26	1.47	1.41	0.81	0.76	2.05	2.03	0.30	0.32
New L.S.D at 5%	**0.06**	**0.05**	**0.03**	**0.03**	**0.04**	**0.04**	**0.03**	**0.03**	**0.09**	**0.10**	**0.03**	**0.03**

Table (4): Effect of spraying boric acid and /or glutathione on the percentages of fruit retention, yield, fruit weight, height and diameter of "Keitte" mango trees during 2014 and 2015 seasons

Treatment	Fruit retention %		No. of fruits/tree		Yield/tree (kg.)		Fruit weight (g.)		Fruit height (cm)		Fruit diameter (cm)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control (trees sprayed with water)	0.71	0.72	36.0	35.0	14.2	13.9	395.0	397.0	11.0	10.9	7.9	7.7
Boric acid at 0.025%	0.78	0.81	38.0	38.0	15.2	15.3	401.0	403.0	11.3	11.2	8.1	7.9
Boric acid at 0.05%	0.85	0.89	40.0	40.0	16.4	16.5	410.0	411.7	11.6	11.5	8.3	8.1
Boric acid at 0.1%	0.86	0.90	41.0	40.0	16.9	16.5	411.0	412.0	11.7	11.6	8.3	8.1
Glutathione at 0.025%	0.99	0.97	42.0	43.0	17.5	18.0	417.0	419.0	12.0	11.9	8.5	8.3
Glutathione at 0.05%	1.01	1.05	44.0	45.0	18.6	19.1	422.0	425.0	12.2	12.1	8.7	8.5
Glutathione at 0.1%	1.02	1.06	44.0	45.0	18.6	19.2	423.0	425.9	12.3	12.4	8.8	8.6
Both at 0.025%	1.10	1.15	46.0	47.0	20.2	20.4	439.0	433.0	12.5	12.5	9.0	8.8
Both at 0.05%	1.16	1.22	48.0	49.0	21.7	21.5	452.0	439.0	12.7	12.8	9.2	9.0
Both at 0.1%	1.17	1.23	48.0	50.0	21.7	22.0	453.0	440.0	12.7	12.9	9.3	9.0
New L.S.D at 5%	**0.06**	**0.07**	**2.0**	**2.0**	**0.7**	**0.8**	**5.0**	**5.1**	**0.2**	**0.2**	**0.2**	**0.2**

Table (5): Effect of spraying boric acid and/or glutathione on some physical and chemical fruit characteristics of "Keitte" mango trees during 2014 and 2015 seasons

Treatment	Fruit thickness (cm)		Seed weight %		Peel thickness (mm)		Pulp %		Edible/non-edible portions of fruit		T.S.S.%	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control (trees sprayed with water)	7.0	6.7	10.0	10.5	14.0	13.9	76.0	75.6	3.2	3.1	9.0	9.3
Boric acid at 0.025%	7.2	6.9	9.8	10.2	13.7	13.6	76.5	76.2	3.3	3.2	9.4	9.7
Boric acid at 0.05%	7.5	7.2	9.5	10.0	13.4	13.2	77.1	76.8	3.4	3.3	9.7	10.0
Boric acid at 0.1%	7.5	7.2	9.4	9.9	13.3	13.1	77.3	77.0	3.4	3.3	9.8	10.0
Glutathione at 0.025%	7.7	7.5	9.3	9.4	13.0	12.8	77.7	77.2	3.5	3.4	10.2	10.4
Glutathione at 0.05%	7.9	7.7	9.0	9.0	12.7	12.5	78.3	77.5	3.6	3.4	10.6	10.8
Glutathione at 0.1%	8.0	7.8	9.0	8.9	12.6	12.4	78.4	78.7	3.6	3.7	10.7	10.9
Both at 0.025%	8.2	8.0	8.8	8.7	12.2	12.0	79.0	79.3	3.8	3.8	11.1	11.3
Both at 0.05%	8.5	8.2	8.5	8.5	12.0	11.8	79.5	79.7	3.9	3.9	11.5	11.6
Both at 0.1%	8.5	8.2	8.4	8.5	11.9	11.8	79.7	79.7	3.9	3.9	11.6	11.7
New L.S.D at 5%	**0.2**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**0.4**	**0.4**	**0.2**	**0.2**	**0.3**	**0.3**

Table (6): Effect of spraying boric acid and/or glutathione on some fruit chemical characteristics of "Keitte" mango trees during 2014 and 2015 seasons

Treatment	Total acidity %		Total sugars%		Reducing sugars%		Vitamin C content (mg/100 ml juice)		Total fibre %	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control (trees sprayed with water)	0.764	0.781	7.1	6.8	3.1	3.0	44.6	46.0	1.11	1.09
Boric acid at 0.025%	0.744	0.761	7.3	7.1	3.3	3.2	45.7	47.3	1.03	1.00
Boric acid at 0.05%	0.711	0.728	7.6	7.4	3.5	3.4	47.0	48.5	1.00	0.93
Boric acid at 0.1%	0.709	0.725	7.7	7.5	3.6	3.5	47.3	48.7	0.91	0.92
Glutathione at 0.025%	0.680	0.705	7.9	7.7	3.8	3.7	48.5	50.0	0.94	0.86
Glutathione at 0.05%	0.661	0.671	8.1	7.9	4.0	4.0	44.6	51.3	0.88	0.80
Glutathione at 0.1%	0.659	0.650	8.1	8.0	4.1	4.1	50.0	51.6	0.87	0.78
Both at 0.025%	0.621	0.619	8.3	8.2	4.3	4.3	51.9	52.7	0.75	0.74
Both at 0.05%	0.601	0.594	8.6	8.5	4.5	4.6	54.0	54.0	0.69	0.70
Both at 0.1%	0.600	0.593	8.6	8.6	4.6	4.7	54.3	54.3	0.68	0.67
New L.S.D at 5%	**0.015**	**0.014**	**0.2**	**0.2**	**0.2**	**0.2**	**0.9**	**1.0**	**0.02**	**0.02**

Percentages of fruit retention and yield

Data in Table (4) obviously reveal that fruit retention % as well as yield expressed as weight and number of fruits/tree were significantly improved in response to the tested treatments as compared to the control. Combined applications were superior than using each material alone in enhancing fruit retention and yield/tree. Among the combined treatments, the highest fruit retention (1.17 and 1.23%), number of fruit per tree (48.0 and 50.0%) and yield/ tree (21.7 and 22.0 Kg) resulted from trees treated by combined treatment at 0.1%, with increments over the control by (64.7 and 70.8%) for fruit retention, (33.3 and 42.8) for number of fruit per tree and (52.8 and 58.2%) for yield / tree in the first and second seasons, respectively, without significant differences with those treated by the same combined treatments but at .05%. Therefore, from the economical point of view, it is advised to use this treatment at 0.05%to obtain acceptable yield of "Keitte" mango trees grown under sandy calcareous soil. Under such promising treatment, yield per tree reached 21.7 and 21.5 kg while the untreated trees produced 14.2 and 13.9 kg during both seasons, respectively. The percentage of increment on the yield due to this application over the control reached 52.8 and 54.7% during both seasons, respectively. These results were true during both seasons.

Fruit quality

It is evident from the data in Tables (4 to 6) that subjecting "Keitte" mango trees three times to boric acid and/or glutathione each at 0.025 up to 0.1% significantly was responsible for improving quality of the fruits in terms of increasing weight, height, diameter and thickness of fruit, pulp%, edible to non-edible portion of the fruit, T.S.S.%, total and reducing sugars% and vitamin C content and decreasing percentages of seeds and peels, total acidity% and total fiber as compared to the control. Using glutathione was significantly favorable than using boric acid in enhancing fruit quality. Using boric acid combined with glutathione significantly surpassed the application of each solitary in enhancing fruit quality. Increasing concentrations of boric acid and glutathione from each at 0.05 to 0.1% failed significantly to show significant promotion on quality parameters. From economical point of view, it is suggested to sprays a mixture of boric acid and glutathione each at 0.05% for producing acceptable fruits with good quality. Untreated trees produced the lowest fruit quality. These results were true during both seasons.

DISCUSSION

The outstanding effect of glutathione on enhancing the biosynthesis of proteins, sugars, amino acids and sulphur compounds as well as stimulating cell division and preventing the release of reactive oxygen species (ROS) and protecting the plant cells from senescence could explain the present results. The positive action of glutathione on enhancing the tolerance of plants to all biotic and a biotic stresses especially drought conditions (Rennenberg, 1982; Meister and Anderson, 1983; Jorge *et al.,* 1993; Foyer and Lelandias, 1993; Szala *et al*., 2008) could result in enhancing growth and fruiting of fruit crops.

These results are in agreement with those obtained by Mahgoub-Mona *et al*. (2006), El-Khawaga *et al*. (2007), Mohamed (2012), Abdelaal *et al*. (2012), Gad El-Kareem (2012), Ahmed *et al*. (2012), El-Khawaga and Mansour (2014), and Gaber (2016).

The beneficial effects of boron on growth, tree nutritional status, fruit setting, yield and fruit quality of "Keitte" mango trees might be attributed to its positive function on stimulating the biosynthesis and translocation of sugars, cell division, root development, germination of pollen tubes, building of natural hormones as well as the uptake of most nutrient and water (Mengel *et al*., 2001).The beneficial effects of boron on preventing the dropping of flowers, formation of starch and the incidence of different disorders could add good explanation (Perica *et al*., 2001 and Marschner, 2012). The outstanding effect of boron on advancing fruit maturity was reported by (Ahmad *et al*., 2009).

These results are in agreement with those obtained by Abdalla (2005), Harhash and Abdel-Nasser (2010), Gamal (2013), Hassan-Huda (2014), Mohamed *et al*. (2015), Abd El-Wahab (2015), Mahmoud (2015), Abdelbaky (2015), Mahmoud (2016), and Habasy-Randa *et al*. (2016).

CONCLUSION

For promoting yield and fruit quality of "Keitte" mango trees grown under sandy calcareous soil, it is advised to spray boric acid plus glutathione each at 0.05% three times at monthly intervals starting from the first week of March.

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علاقة الإثمار في أشجار المانجو الكيت بإستخدام الجلوتاثيون والبورون

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أجريت هذه الدراسة خلال موسمي ٢٠١٤، ٢٠١٥ لاختبار تأثير رش حامض البوريك والجلوتاثيون بالصورة الفردية أو المشتركة بتركيز ٠.٠٥ إلي ٠.١% ثلاث مرات علي فترات شهريه ابتداء من أول مارس على النمو، الحالة الغذائية للأشجار، كمية المحصول وخصائص الجودة للثمار في أشجار المانجو الكيت النامية في التربة الرملية الجيرية. كان هناك تحسن ملحوظ في جميع الصفات الخضرية والصبغات والعناصر الغذائية في الأوراق والنسبة المئوية للعقد النهائي وكمية المحصول ومقاييس الجودة للثمار عند معاملة الأشجار بهذه المعاملات المختبرة. وكان هناك تفوق ملحوظ للجلوتاثيون علي حامض البوريك في هذا الصدد، كذلك كان استخدام المادتين معا أفضل من استخدام أية مادة بمفردها. كانت المعاملة المتميزة هي تلك التي تضمنت استخدام حامض البوريك مع الجلوتاثيون بتركيز٠.٠٥ ، ٠.١% وبدون فروق معنوية بينهما. لذلك من الوجهة الاقتصادية فانه ينصح باستخدام هذه المعاملة عند تركيز ٠.٠٥% للحصول علي أعلي محصول وثمار ذات صفات مقبولة لأشجار المانجو صنف الكيت النامية تحت الظروف المصرية.

الكلمات الدالة: أشجار المانجو الكيت ، حمض البوريك ، الجلوتاثيون ، عدد مرات الرش ، كمية المحصول ، خصائص الجودة للثمار