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Productivity and Fruit Quality of Three Mango Cultivars in Relation to Foliar Sprays of Calcium, Zinc, Boron or Potassium

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Abstract: The experiment was carried out during 2008 and 2009 seasons, conducted in an orchard located in El-Kassasien Horticulture Research Station, Ismailia Governorate, Egypt. Langara, Ewais, Alphonso mango cultivars trees of 18 years old were sprayed at stages: i.e., bud emergence, full bloom and pea stage with calcium nitrate at 2%, zinc sulfate at 0.4%, boric acid at 0.2% or potassium nitrate at 2%. The results indicated that, spraying with foliar nutrients were significantly increased number of fruits/tree, fruit set, yield/tree and improved quality as well as physiological and chemical properties of fruits. As calcium nitrate at 2% and potassium nitrate at 2% sprayed were the most effective treatments in enhancing the yield. Further investigations are required to test combined treatments of both compounds in addition to boric acid which had supreme effect on initial fruit set.

Key words: Mango · Calcium nitrate · Zinc sulfate · Boric acid · Potassium nitrate · Fruit quality · Yield

INTRODUCTION

Mangoes (*Mangifera indica* L.) considered the king of fruits in plenty of the countries world wide. Mangoes cultivation extended rapidly in Egypt to reach 14444965 feddans producing 534434 tons and the average production/feddan is 3.687 tons according to Ministry of Agriculture [1]. This production average is rather low and even it is not consistent due to several reasons as biennial bearing, low fruit set and high abscission rates [2]. Attempts were made by several researchers to enhance the productivity and quality of mangoes via foliar applications of nutrients. Jutamanee *et al.* [3], Singh and Maurya [4] and Vish Wakarma *et al.* [5] showed enhancement of mango productivity as a result of boron application. It also resulted in improving the fruit quality of mango in term of weight, TSS%, total sugars and coloration due to boron application [6-8]. The attained effects might be attributed to the effect of boron on enhancing pollen germination, pollen tube growth, sugar synthesis and accumulation [9, 10].

Calcium spraying increased the productivity of mango basically due to reducing abscission [11, 12]. Enhancements in fruit quality parameters as increasing the flesh firmness were also induced on mango cv. Tommy Atkins [13]. The attained results were due to its' effect of calcium on maintained the middle lamella cells [14].

Productivity of several mango cultivars was improved by potassium spray [15]. It resulted also in improving the fruit quality parameters: i.e., TSS%, total sugars and coloration [7, 16]. These effects might be dedicated to the potassium role in increasing tolerance to stresses and improving the formation and accumulation rates of sugars [17, 12].

The positive effect of foliar application of zinc in increasing the productivity of mango was cited by Singh and Maurya [4] and Ranjit *et al.* [18] and improved the fruit quality in terms of Rashmi and singh [6].

The scope of the currant investigation is to find out the comparative effect of calcium nitrate, zinc sulfate, boric acid and potassium nitrate on the productivity and fruit quality of three mango cultivars.

MATERIALS AND METHODS

The present investigation was carried out on three mango cultivars: i.e., Alphonso, Langara and Ewais during two successive seasons of 2008 and 2009. Trees were 18 years old at the beginning of the investigation and grown in sandy soil at El-Kassasien Horticulture Research Station located in Ismailia Governorate. They were spaced 7×7m, irrigated by drip irrigation system and subjected to cultural practices

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recommended by the ministry of Agriculture. Forty five uniform trees of each cultivar were selected for this investigation. The randomized complete blocks design was adopted. Each three trees of each cultivar (each tree acting as a replicate) were sprayed at the bud emergence, full bloom and pea stage with one of the following treatments: zinc sulfate ($ZnsO_4$) at 0.4%, calcium nitrate ($Ca(NO_3)_2$) at 2%, potassium nitrate (KNO_3) at 2% or boric acid (H_3PO_3) at 0.2% and control (sprayed with water only).

The Following Were Determined for Each Tree

Fruiting Parameters: At full bloom 40 panicles/tree distributed at the four directions were chosen at random and tagged. The following were determined: number of fruit set/panicle (15 days after petal fall), number of retained fruits/panicle (at harvest) and percentage of retained fruits at harvest (percentage of retained fruits = average number of retained fruits per panicle at harvest/average number of initial fruit set per panicle ×100).

Yield (kg/tree): Was estimated at harvest by multiplying the number of fruits born on each tree × average fruit weight.

Fruit Quality: Samples of five mature fruits per tree were randomly taken and kept in laboratory till ripe stage [19]. The following fruit quality parameters were assessed: Fruit weight (g), flesh thickness (cm) by a vernier caliper, flesh firmness (Ib/inch2) using a Mecmesin, force torque instrument equipped with 1.1 cm diameter probe, juice total soluble solids percentage (TSS%) using an Abb. digital refractometer, juice total acidity percentage as citric acid, vitamin C (mg/100g F.w.) according to A.O.A.C [20] and total sugars (mg/100g F.w.) according to Smith *et al.* [21].

Statistical Analysis: The attained data were tabulated and statistically analyzed according to Snedecor and Cachran [22]. The mean values were compared by LSD at 5% level of probability.

RESULTS AND DISCUSSION

Fruiting Parameters

Number of Initial Fruit Set/panicle: On the average significantly the least number of fruit set/panicle was found on control trees (Table, 1). The considered treatments increased this number significantly. Statistically the highest number of fruit set/panicle was due to the boric acid treatment in both seasons. On the average Ewais cultivar attained the highest number of fruit set 15 days after petal fall compared with both Langara and Alphonso cultivars. Interaction data reveal that, for each considered cultivar boric acid treatment resulted in significantly the highest effect compared with control and remaining treatments.

Number of Retained Fruits/panicle: On the average calcium nitrate resulted in significantly the highest number of retained fruits/panicle compared with control and remaining treatments (Table, 2). Panicles of Ewais cultivar retained significantly the highest number of fruits on the average compared with the other cultivars. Interaction data demonstrates that for both Langara and Ewais cultivars, calcium nitrate resulted in significantly the highest number of retained fruits/panicle. Comparable results were due to boric acid treatment for Langara cultivar in the first season only. As for Alphonso cultivar highest number of retained fruits/panicle was due to calcium nitrate treatment in both seasons. This number was statistically equal to number attained by all treatments in the first season and to that attained by boric acid treatment in the second one.

Table 1: Effect of foliar treatments on number of initial fruit set/panicle during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	28.50	34.25	24.91	29.22	27.33	32.91	24.00	28.08
Calcium nitrate	29.50	33.41	30.58	31.16	28.58	32.66	28.83	30.02
Zinc sulfate	34.75	44.08	34.00	37.61	28.50	42.75	32.83	34.69
Boric acid	54.00	62.25	40.91	52.38	50.58	58.08	36.83	48.50
Potassium nitrate	33.16	44.16	33.16	36.83	32.25	42.00	27.50	33.91
Mean(A)	35.98	43.63	32.71		33.45	41.68	30.00	

LSD. at 5% (Season 2008 A= 0.99 B= 1.28 AXB= 2.22) (Season 2009 A= 0.87 B= 1.13 AXB=1.96)

Table 2: Effect of foliar treatments on number of retained fruits/panicle at harvest during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	0.66	1.41	0.58	0.88	0.83	1.50	0.66	1.00
Calcium nitrate	2.58	3.83	1.25	2.55	2.58	3.83	1.33	2.58
Zinc sulfate	1.41	1.75	0.83	1.33	1.58	1.83	0.83	1.41
Boric acid	2.16	2.50	1.00	1.88	2.16	2.50	1.08	1.91
Potassium nitrate	1.25	1.83	0.83	1.30	1.25	2.08	0.91	1.41
Mean(A)	1.61	2.26	0.90		1.68	2.35	0.96	

LSD. at 5% (Season 2008 A= 0.18 B= 0.24 AXB= 0.42) (Season 2009 A= 0.16 B= 0.21 AXB=0.37)

Table 3: Effect of foliar treatments on fruit retention percentage during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	2.31	3.95	2.40	2.88	2.95	4.15	2.85	3.31
Calcium nitrate	8.77	11.70	4.00	8.15	8.43	11.12	4.33	7.96
Zinc sulfate	3.69	4.20	2.65	3.15	3.93	4.38	2.96	3.75
Boric acid	4.42	5.23	2.85	4.16	4.69	5.65	3.15	4.49
Potassium nitrate	4.53	5.85	3.01	4.46	4.87	5.93	3.36	4.72
Mean(A)	4.74	6.18	2.98		4.97	6.24	3.33	

LSD. at 0.5% (Season 2008 A = 0.59 B = 0.76 A X B = 1.31) (Season 2009 A = 0.55 B = 0.71 A X B = 1.22)

Table 4: Effect of foliar treatments on yield of tree (kg) during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	29.9	10.2	15.8	18.6	26.6	10.5	13.4	16.8
Calcium nitrate	45.1	22.9	22.3	30.1	41.1	22.0	18.5	27.2
Zinc sulfate	39.9	15.9	19.9	25.2	30.5	15.5	16.7	20.9
Boric acid	44.5	16.1	20.7	27.1	40.5	18.8	22.0	27.1
Potassium nitrate	45.0	20.4	26.1	30.5	42.3	16.5	23.3	27.3
Mean(A)	40.88	17.1	20.96		36.2	16.66	18.78	

LSD. at 0.5% (Season 2008 A= 1.32 B= 1.70 AXB= 2.9) (Season 2009 A= 1.16 B= 1.51 AXB= 2.61)

Table 5: Effect of foliar treatments on fruit weight (g) during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	292.6	180.5	237.5	236.8	255.0	174.2	202.4	210.5
Calcium nitrate	355.3	237.8	270.3	287.8	306.5	212.7	216.9	245.3
Zinc sulfate	374.6	256.8	317.1	316.1	295.3	229.5	260.7	261.8
Boric acid	383.0	250.3	358.6	330.6	322.6	233.4	279.9	278.6
Potassium nitrate	406.6	247.6	296.5	316.9	382.9	237.2	293.2	304.4
Mean(A)	362.42	234.6	296.0		312.46	217.4	250.62	

LSD at 0.5% (Season1 A= 32.48 B = 41.93 A X B = N.S) (Season2 A= 26.71 B =34.48 AX B= N.S)

Table 6: Effect of foliar treatments on fruit pulp thickness (cm) during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	2.22	1.77	2.22	2.07	2.23	1.80	1.75	1.92
Calcium nitrate	2.40	1.99	2.18	2.19	2.50	1.90	2.00	2.13
Zinc sulfate	2.44	1.88	2.50	2.27	2.48	2.07	2.23	2.26
Boric acid	2.56	2.16	2.43	2.38	2.49	2.01	2.31	2.27
Potassium nitrate	2.59	2.01	2.39	2.33	2.70	2.04	2.65	2.46
Mean (A)	2.44	1.96	2.34		2.48	1.96	2.18	

LSD. at 0.5% (Season 2008 A= 0.15 B= 0.20 AXB= N.S) (Season 2009 A= 0.13 B= 0.18 AXB= N.S)

Table 7: Effect of foliar treatments on fruits firmness during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	3.10	3.26	3.16	3.17	3.12	3.21	3.15	3.16
Calcium nitrate	3.82	4.01	3.79	3.87	3.79	3.92	3.76	3.82
Zinc sulfate	3.15	3.19	3.25	3.19	3.20	3.25	3.22	3.22
Boric acid	3.19	3.17	3.17	3.18	3.16	3.20	3.19	3.18
Potassium nitrate	3.25	3.36	3.33	3.31	3.35	3.36	3.31	3.34
Mean(A)	3.34	3.39	3.37		3.32	3.38	3.32	

LSD. at 0.5% (Season 2008 A= 0.04 B= 0.06 AXB= 0.10) (Season2 A= 0.03 B= 0.04 AXB= 0.07)

Table 8: Effect of foliar treatments on total soluble solids (TSS%) during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	14.50	15.50	15.00	15.00	15.33	16.00	15.50	15.61
Calcium nitrate	15.50	15.50	14.83	15.27	15.16	16.16	15.83	15.72
Zinc sulfate	16.11	16.60	15.66	16.12	16.66	16.50	16.16	16.44
Boric acid	16.16	19.66	16.00	17.27	16.00	20.16	16.50	17.55
Potassium nitrate	17.00	20.83	17.50	18.44	17.60	21.16	18.00	18.92
Mean(A)	15.85	17.53	15.79		16.15	18.00	16.39	

LSD. at 0.5% (Season 2008 A= 0.42 B= 0.54 AXB= 0.94) (Season 2009 A= 0.54 B= 0.69 AXB=1.21)

Table 9: Effect of foliar treatments on fruit acidity (%) during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	2.70	1.80	2.30	2.26	2.63	1.76	2.25	2.21
Calcium nitrate	2.58	1.72	2.38	2.22	2.55	1.73	2.33	2.20
Zinc sulfate	2.49	1.71	2.28	2.16	2.46	1.70	2.23	2.13
Boric acid	2.56	1.76	2.20	2.17	2.53	1.71	2.13	2.12
Potassium nitrate	2.48	1.63	2.05	2.05	2.36	1.60	2.00	1.98
Mean(A)	2.56	1.72	2.24		2.50	1.70	2.18	

LSD. at 0.5% (Season 2008 A = 1.25 B = 1.62 A X B =N.S) (Season 2009 A = 1.06 B = 1.37 A X B = N.S)

Table 10: Effect of foliar treatments on vitamin C (mg/100g F.W) during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	17.50	21.00	20.40	19.63	17.86	21.60	20.80	20.08
Calcium nitrate	17.96	21.56	20.26	19.92	18.20	22.00	21.10	20.43
Zinc sulfate	18.20	21.00	20.86	20.02	18.43	21.30	17.36	19.03
Boric acid	18.03	21.43	20.66	20.04	18.50	21.70	21.23	20.47
Potassium nitrate	19.63	23.76	22.50	21.96	20.20	24.26	23.33	22.59
Mean(A)	16.42	24.38	30.52		17.82	25.38	31.12	

LSD at 0.5% (Season1 A = 1.60 B = 2.07 A X B =N.S) (Season2 A = 1.23 B = 1.58 A X B = N.S)

Table 11: Effect of foliar treatments on total sugars (mg/100g F.W) during 2008 and 2009 seasons

	Season 2008				Season 2009			
	Cultivars				Cultivars			
Treatments	Langara	Ewais	Alphonso	Mean (B)	Langara	Ewais	Alphonso	Mean (B)
Control	10.23	12.46	11.16	11.28	10.23	12.56	11.33	11.37
Calcium nitrate	10.16	12.23	11.10	11.16	10.26	12.33	11.13	11.24
Zinc sulfate	10.50	12.70	11.66	11.62	10.66	12.90	11.83	11.80
Boric acid	10.50	13.56	11.86	11.97	10.36	13.80	12.13	12.10
Potassium nitrate	11.16	14.06	12.43	12.55	11.20	14.23	12.76	12.73
Mean(A)	10.51	13.00	11.64		10.54	13.16	11.84	

LSD. at 0.5% (Season 2008 A = 0.17 B = 0.22 A X B =0.39) (Season 2009 A = 0.19 B = 0.25 A XB=0.43)

Percentage of Retained Fruits: On the average significantly the highest percentage of retained fruits was attributed to the calcium nitrate treatment compared to control and remaining treatments (Table, 3). Compared with all considered cultivar, Ewais cultivar attained the highest percentage of fruit retention in both seasons. Interaction data illustrate that for both Langara and Ewais cultivars statistically the highest percentage of fruit retention was due to calcium nitrate treatment. As for Alphonso cultivar all treatments had statistically equal increasing effects except for the zinc sulfate which had a lower effect but still significantly higher than control.

Yield: On the average control untreated trees bore significantly the least yield. The yield was significantly increased by all of the considered treatments. Significantly the highest yield was due both potassium nitrate and calcium nitrate treatments with insignificant differences between them. In the second season however, the boric acid treatment resulted in statistically equal effect. Langara trees bore significantly the highest yield in both seasons of the investigation. Interaction data clarify that, for all cultivars although all treatments increased the yield significantly compared with control comparative effects of conducted treatments varied. With Langara cultivar all treatments were statistically equal except for zinc sulfate which had a significantly lower effect. Boric acid and calcium nitrate resulted in significantly highest yield in both seasons with Ewais. Whereas with Alphonso cultivar superiority was dedicated to potassium nitrate in both season with insignificant differences from both boric acid and calcium nitrate in the second season only.

Fruit Quality Parameters

Average Fruit Weight: All of the conducted treatments significantly increased the average fruit weight compared with control in both seasons. In the first season heaviest fruits were due to boric acid treatment with insignificant differences from both potassium nitrate and zinc sulfate treatments. However, in the second season superiority was due to potassium nitrate treatment with insignificant differences from both boric acid and zinc sulfate treatments. On the average Langara fruits were significantly the heaviest in both seasons. Interaction data were insignificant in both seasons.

Pulp Thickness: Pulp thickness was increased by the conducted treatments. The increments due to both calcium nitrate and zinc sulfate treatments in the first

season were statistically equal pto control. The highest effect was significantly due to both boric acid and potassium nitrate in the first season and due to potassium nitrate only in the second one. On the average pulp thickness was significantly the highest in Langara cultivar with insignificant difference from that of Alphonso cultivar in the first season only. Interaction results were insignificant in both seasons.

Fruit Firmness (Flesh): On the average calcium nitrate resulted in significantly the highest fruit firmness compared with control and remaining treatments in both seasons. Highest fruit firmness was achieved by Ewais fruits in both seasons with insignificant differences from Alphonso in the first season only. Interaction data clarify that, in general all treatment increased this parameter in all of the considered cultivars except for the boric acid treatment in both seasons and zinc sulfate in the first season which resulted in decreasing it compared with the control. This decrease was only significant in the second season. As for the increasing effect it was significantly the highest with calcium nitrate treatment for all cultivars.

TSS%: On the average the conducted treatments increased the juice TSS% compared with control. Yet, increments due to calcium nitrate treatment were insignificantly different from control. Highest significant juice TSS% was due to the potassium nitrate treatment. Ewais fruit attained significantly the highest juice TSS% in both seasons. Interaction results show that, for all cultivars highest juice TSS% was due to the potassium nitrate treatment. Comparable results were due to both boric acid and zinc sulfate treatments in the case of Langara cultivar and boric acid in the case of Alphonso cultivar in the first season only.

Juice Acidity %: The conducted treatments did not alter the juice acidity significantly compared with control except for potassium nitrate which induced a significant reduction. On the average Ewais cultivar attained significantly the least juice acidity percentage. Interaction data were not significant in both considered seasons.

Vitamin C Content: Compared with control and the remaining treatment potassium nitrate treatment resulted in significantly the highest vitamin C content. Whereas other treatments were statistically equal to control. Alphonso cultivar attained significantly the highest vitamin C content. The interaction data were not significant in both seasons.

Total Sugars Content: All treatments except calcium nitrate induced significant increments in this parameter on the average. Highest significant effect was attributed to the potassium nitrate treatment. Ewais cultivar on the average attained significantly the highest fruit total sugars content. Interaction data show that, for all considered cultivars the significantly the highest fruit total sugars percentage was due potassium nitrate treatment. Comparable results were due to the boric acid treatment in Ewais cultivar in the second season only.

Boric acid resulted in significantly the highest number of fruit set/panicle. The attained results are in agreement with those by Zhong Runi and Dong, [23], Saleh and El-Monem [17] and Singh and Maurya [4] all emphasized on the effect of boron on increasing the initial fruit set in mangoes. This effect might be due to the effect of boric acid on enhancing the pollen grain germination and pollen tube elongation which consequently leads to better fruit set [24]. Yet this treatment did lead to highest yield.

Calcium nitrate resulted in the highest tree yield. This result was due to the highest reduction in fruit abscission induced by this compound which led to highest number of retained fruits/panicle.

Parallel results were found by Kumar *et al.* [25] and Hafle *et al.* [26] who reported that, foliar spray of calcium nitrate at 2% recorded the highest number of fruits per tree. This might be due to that, calcium sprays well maintained that the middle lamella between plant cells which lead to decries fruits drop [13].

Potassium nitrate had comparable results with respect to the yield. This might be due to clear enhancements in average fruit weight dedicated to this compound. Similar findings were achieved by Dalal *et al.* [27] on mango cv. Pairi; Khattab *et al.* [28] on mango cv. Ewais and Sidik; Shinde *et al.* [29] on mango cv. Alphonso. These results might be due to effects of KNO_3 [30].

As for the effect of tested treatments on quality attributes, potassium nitrate induced the highest juice TSS%, vitamin C content and sugars content and the least juice acidity percentage. In addition to its positive effects on fruit weight and flesh thickness.

The afore mentioned findings are similar with those of Eliwa [16]; Abd-Allah [8]; Shinde *et al.* [29] and Kumar *et al.* [25] who stressed on the effect of potassium on these parameters. These findings night be due to potassium effect on enhancing the synthesis and accumulation of sugars [12].

Flesh firmness was significantly the highest with calcium nitrate treatment. Parallel results were attained by Conway *et al.* [14] and these results might be dedicated to thus leading to better firmness.

In conclusion calcium nitrate at 2% and potassium nitrate at 2% sprayed at bud emergence, full bloom and pea stage were the most effective treatments in enhancing the yield due to decreasing abscission in the case of the former and enhancing fruit weight in the case of the later both compounds had positive effects on fruit quality. Further investigations are required to test combined treatments of both compounds in addition to boric acid which had supreme effect on initial fruit set.

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