Response of Mango Trees to Date and Number of Chelated Fe, Zn and Mn Foliar Sprays

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ABSTRACT

The present investigation was conducted during 2005 and 2006 seasons to evaluate date and number of foliar applications of chelated iron, zinc and manganese to Hindi-Be-Senara mango trees. The spraying dates were; in February (before full bloom), March (at full bloom), April (before fruit set) and May (at fruit set). The application of one spray in April followed by another in May proved to be the most effective foliar application date. However, the dates of applications of February and May, March and May or April and May were superior for the two times foliar sprays. Spraying the chelated Fe + Zn + Mn once or twice times in any application date caused a significant increase in leaf Mg, Fe, Zn, Mn and chlorophyll contents and shoot length during both seasons. In general, spraying one or two foliar sprays resulted in a marked increase in fruit set, fruit retention and yield and decreased fruit drop. The foliar spray treatments increased fruit TSS and V.C contents, whereas, leaf N, P, K and Ca, fruit acidity, length and diameter were not affected.

INTRODUCTION

Recently, mango is starting to occupy a great acreage among all fruit trees grown in Egypt and the factors controlling its growth productivity are receiving the attention of many investigators (Kassem and Marzouk, 2004). The nutritional status of the fruit tree is known to be one of the most important factors influencing its growth and productivity (Kulkarny, 2004). To introduce the foliar feeding method in the fertilization program of a fruit tree, it would be desirable first to determine the best date, rate and number of foliar applications needed (Taha *et al.*, 1979). So far, most of the attention was given for establishing the best form and rate of applying different nutrients to the tree's foliage, while the suitable date and number of application was not extensively studied (Taha *et al.*, 1979). Accordingly, the present study was carried out in order to evaluate the application time and number of chelated iron, zinc and manganese foliar sprays applied to mango trees. Zinc is known to be important for flowering and fruit set (Bahadur *et al.*, 1998). Also, Swietlik (2002) indicated that foliar applied Zn necessitates repeated spray application in order to obtain its effect.

MATERIALS AND METHODS

The present study was carried out during 2005 and 2006 growing seasons on 23 years old Hindi-Be-Senara mango trees (*Mangifera indica* L.) grown in Abo El-Matameer region near Alexandria.

The soil was sandy clay, well drained with water table about 140 cm. Trees were planted at 6x7 m apart and irrigated with Nile water every 15 days. The orchard was fertilized with organic manure and calcium superphosphate at the rate of 20 cubic meters and 150 kg per feddan, respectively, in December every season. Also, ammonium nitrate (350 kg/fed.) was applied at two equal doses at mid-March and mid-June of each season. The physical and chemical properties of the orchard soil are presented in Table (1).

Table (1): Soil analysis of the experimental orchard.

Soil analysis	Soil depth (cm)		
	0 - 30	30 - 60	60 - 90
Cations, meq/l			
Ca	7.82	6.48	13.92
Mg	3.85	6.35	0.66
Na	2.16	1.97	2.73
K	0.58	0.51	0.44
Cations, ppm			
P	6.47	1.24	0.92
Fe	2.02	2.00	1.94
Cu	1.56	1.32	0.95
Mn	5.49	4.81	6.30
Zn	0.98	0.96	1.10
$CaCO_3$	23.76	31.3	35.6
pH	7.68	7.78	7.68
EC (mmhos/cm)	1.23	1.27	1.96
Organic matter (%)	2.76	0.94	0.68
Texture	sandy clay loam	sandy loam	sandy loam

Eleven foliar spray treatments with a solution containing chelated 0.1% Fe + 0.05% Zn + 0.05 Mn and water sprayer control were arranged in a randomized complete block design. Each treatment included five replications with one tree for each replicate. The solution was applied once or twice in the following dates: February (before full bloom), March (at full bloom), April (before fruit set) and May (at fruit set) and the eleven treatments were as follows:

1. Control (water spray only).
2. One spray in February.
3. One spray in March.
4. One spray in April.
5. One spray in May.
6. Two sprays in February and March.
7. Two sprays in February and April.
8. Two sprays in February and May.
9. Two sprays in March and April.
10. Two sprays in March and May.
11. Two sprays in April and May.

Each tree received approximately 7 liters of the spray solution and the surfactant Biofilm (30 cm/100 l water) produced by Biotech-Egypt was added to the spray solution to obtain best spreading. The effect of the different treatments on tree growth as shoot length was estimated as follows: five main branches were tagged on the different sides of each tree in February and the length of spring non-fruiting shoots per branch was measured in September of both seasons. Also, the number of fruits on each panicle of the tagged branches was recorded after fruit set (late-May) and after June drop (late-June). Fruit set and fruit retention were then calculated as follow:

Fruit set = Average fruits number per panicle

Fruit retention = Number of remained fruits per tree after June drop / number of fruits per tree after fruit set.

Yield as kilogram (kg) and number of fruits per tree was recorded at harvest time (mid-September) of both seasons.

In order to determine leaf Fe, Zn, Mn and chlorophyll contents, leaf samples were collected in mid-September of both seasons at random from the medium parts of the non-fruiting previously tagged spring shoots. Each leaf sample consisted of 30 leaves for each replicate. A leaf sample of 25 leaves was thoroughly washed with tap water, rinsed twice in distilled water, dried to a constant weight in air drying oven at 70°C, grounded and digested with H_2O_2 and H_2S0_4 according to the method of Evinhauis and De Waard (1980). Iron, zinc and manganese were then determined using an atomic absorption spectrophotometer 305B. Leaf chlorophyll as mg/100 g fresh weight was measured calorimetrically according to Moran and Porth (1980).

For determining fruit quality characters, a sample of twenty fruits were randomly collected once at harvest time from each tree in both 2005 and 2006 seasons. In each sample fruit weight, diameter, length, juice TSS and acidity were determined.

The obtained data were statistically analyzed according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Shoot length

The data presented in Tables 2 and 3 showed that spraying Fe+Zn+Mn once in May and twice in any spraying date significantly increased shoot length in both seasons as compared with the water sprayed control. However, in both seasons no significant differences were observed among the one foliar spray treatments (T2, T3, T4 or T5) and among the two foliar sprays treatments (T6, T7, T8, T9, T10 and T11). El-Kassas (1984a and b), working on Balady lime trees, reported that the vegetative growth was improved under different rates and methods of iron applications. Hassan *et al.* (1995a) estimated an increase in shoot length of Washington Navel orange when sprayed three times with chelated Fe, Zn and Mn. However, Tones *et al.* (2002) indicated that the dry matter of avocado trees was not affected by zinc foliar sprays.

Leaf chlorophyll

The data of 2005 and 2006 seasons revealed that all treatments, except one spray in February in the second season, gave a significant increase in leaf chlorophyll cr mparing with the control (Tables 2 and 3). In addition, trees sprayed twice in February and March (T6) contained lower leaf chlorophyll when compared with trees sprayed twice in February and May, March and May or April and May (T8, T10 and T11) in both seasons. However, no significant differences were observed in both seasons among the treatments number 8, 10 and 11 and among all the one spray treatments (T2, T3 T4 and T5). Qin *et al.* (1993) and Nakhila (1998), working on orange and Supriya and Bhattacharyya (1993), working on lemon, reported that Zn and/or Fe foliar sprays increased leaf chlorophyll content. In addition, Hassan (1995a) reported an increase in leaf chlorophyll content of Valencia orange by spraying chelated Fe, Zn and Mn three times.

Leaf mineral content

The results obtained in both seasons showed that all Fe+Zn+Mn treatments did not significantly affect leaf nitrogen, phosphorous and potassium contents (Tables2 and 3). These findings partially agreed with those obtained by Mann and Sidha (1983) on mandarin, Malavolta and Pomper (1984), El-Shamy *et al.* (1989) and Nakhlla (1998) working on

orange. In addition, magnesium content was significantly increased in both seasons by treatment 5 (one spray in May) and by all the two spray treatments (T6, T7, T8, T9, T10 and T11) as compared with the control. These results agreed with those reported by El-Kassas (1984b) and El-Shamy *et al.* (1989). They found that leaf magnesium content of Balady lime or Navel orange was increased by the certain micro-nutrients foliar applications. However, in both seasons no significant differences in leaf magnesium content were obtained among the one or two spray treatments (Tables 2 and 3).

With regard to the leaf micronutrients content, the data presented in Tables 2 and 3 showed that one or two foliar spray treatments gave a considerable increase in leaf iron content comparing with the water sprayed control. Also, the data revealed that one spray in May (T5) resulted in a higher leaf iron content than one spray in March (T3) in both seasons or one spray in February (T2) in the first season only. Moreover, leaf iron content was significantly higher in trees sprayed twice in February and May (T8), March and May (T10) and April and May (T11) than those sprayed twice in February and march (T6) or March and April (T9) in both seasons (Tables 1 and 2). Similarly, Taha *et al.* (1979) found that iron sprayed in June or in September was absorbed more rapidly than that sprayed in March. Wirth (1973) stated that iron absorption by the leaves is an energy consuming process depending on the photosynthetic energy. Thus, the great synthesis and accumulation of carbohydrates in the leaves during the period from June drop to September seems to support this notation. From the discussion above it might offer a reasonable explanation for the high efficiency of May sprays obtained in the present study. In addition, Patel *et al.*(1997) reported that foliar iron spray increased active and total iron content of the leaves.

With regard to leaf zinc content, it was found that all treatments significantly increased leaf zinc content in both seasons (Tables 2 and 3). Trees sprayed once in May (T5) contained higher leaf zinc than those sprayed once in February (T2), March (T3) or April (T4). In the mean time trees sprayed twice in March and May (T10) or in April and May (T11) contained higher leaf zinc when compared with all other treatments in both seasons (Tables 2 and 3). Generally, the two spray treatments resulted in higher zinc content than the one spray ones. El-Gazzar *et al.* (1979) found that spraying orange trees in May with chelated Fe+Mn +Zn markedly increased zinc content in the leaves. Similarly, Swietlik and La Duke (1991), Wanas *et al.* (1992) and Zeerban *et al.* (1994) indicated that two or three foliar zinc sprays increased leaf zinc content of different citrus cultivars.

Table (2): Effect of Fe, Zn and Mn foliar sprays on shoot length, leaf chlorophyll and leaf mineral content of Hindi-Be-Senara mango trees in 2005.

Treatments	Shoot length (cm)	Chlorophyll content (mg/100 g)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe ppm	Zn ppm	Mn ppm
Control (water spray only)	5.68	212	3.32	0.17	1.37	2.48	0.51	138	20	27
One spray in February	7.78	252	2.16	0.15	1.60	2.12	0.54	157	25	30
One spray in March	8.21	263	1.98	0.17	1.23	2.59	0.56	160	27	34
One spray in April	8.32	270	2.22	0.16	1.42	2.26	0.53	172	29	38
One spray in May	9.68	278	2.06	0.13	1.67	2.47	0.60	178	34	41
Two sprays in February and March	10.13	286	1.99	0.15	1.42	2.51	0.66	186	38	50
Two sprays in February and April	10.35	318	1.99	0.14	1.38	2.65	0.72	202	43	53
Two sprays in February and May	11.77	336	2.10	0.15	1.77	2.52	0.71	230	45	63
Two sprays in March and April	10.86	307	1.95	0.12	1.68	2.31	0.73	220	44	66
Two sprays in March and May	12.36	342	2.23	0.17	1.67	2.47	0.71	238	50	76
Two sprays in April and May	13.52	360	1.97	0.13	1.68	2.52	0.68	241	52	78
$L.S.D_{0.05}$	3.88	40	NS	NS	NS	NS	0.09	17	5	8

Table (3): Effect of Fe, Zn and Mn foliar sprays on shoot length, leaf chlorophyll and leaf mineral content of Hindi-Be-Senara mango trees in 2006.

Treatments	Shoot length (cm)	Chlorophyll content (mg/100 g)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe ppm	Zn ppm	Mn ppm
Control (water spray only)	6.18	220	2.20	0.20	1.40	2.26	0.41	146	21	27
One spray in February	8.26	250	2.32	0.18	1.46	2.50	0.46	161	29	28
One spray in March	7.81	258	2.18	0.21	1.56	2.36	0.43	168	31	30
One spray in April	8.96	255	2.26	0.20	1.60	2.18	0.50	173	30	35
One spray in May	11.72	260	2.11	0.16	1.62	2.36	0.56	189	39	39
Two sprays in February and March	10.89	301	2.06	0.17	1.52	2.48	0.63	196	43	45
Two sprays in February and April	11.08	320	2.13	0.20	1.67	2.36	0.65	213	46	47
Two sprays in February and May	13.86	340	2.26	0.18	1.62	2.50	0.68	236	45	60
Two sprays in March and April	12.12	326	2.36	0.19	1.56	2.40	0.62	213	44	58
Two sprays in March and May	15.62	346	2.30	0.20	1.72	2.48	0.70	240	53	71
Two sprays in April and May	14.72	340	2.28	0.21	1.77	2.36	0.73	256	56	68
$L.S.D_{0.05}$	4.62	35	NS	NS	NS	NS	0.14	21	7	5

As for the manganese content, the data in (Tables 2 and 3) indicated that one spray in April (T4) or in June (T5) increased leaf manganese content in both seasons when compared with the control. However, no significant differences between the two treatments were obtained. In addition, all the two spray treatments (T6, T7, T8, T9, T10 and T11) resulted in a significant higher content of manganese one spray in May (T5) and the control in both seasons. Moreover, the results of both seasons clearly indicated that manganese content was highest by the two sprays treatments in March and May (T10) and in April and May (T11), and was intermediate by two sprays in February and May (T8) and in March and April (T9), and lowest by two sprays in February and March (T6) and in February and April (T7). El-Gazzar *et al.*(1979) reported that Zn+Mn or Fe+Zn+Mn sprays increased leaf manganese content when sprayed in May. Marchanda (1974) reported that foliar application of manganese in mixtures with zinc and/or iron corrected manganese deficiency symptoms of oranges and increased its concentration in the leaves. Taha *et al.* (1979) reported that foliar sprays of manganese were more effective in June or September. In general, two foliar sprays of combination of chelated Fe + Zn +Mn or Mn + Zn were found to increase leaf iron content according to Abd El-Migeed (1996), Hassan (1995a) and El-Safty (1998).

Fruit set and retention

The data presented in Table 5 stated that all treatments (except one spray in May in both seasons and one spray in April in the second season) significantly increased fruit set percent in both seasons comparing with the control. One spray in March (T3) gave a significant higher fruit set percent than one spray in February (T2) and one spray in April (T4).

Also, the data of both seasons indicated that all treatments retained more fruit as compared with the control. Additionally, trees received two sprays in March and April (T9) or in April and May (T11) retained more fruits than the one spray and all other two sprays treatments. These results are in agreement with those of Supriya and Bhattacharyya (1993). They reported that zinc sprays resulted in high fruit set percent of lemon trees. Also, Nakhlla (1998) detected an increase in fruit set and retention of orange trees by spraying zinc 3, 6 or 9 times.

Fruit drop

The data in Table 4 indicated that all spray applications (except one spray in February in both seasons and one spray in March in the first season) significantly decreased fruit drop as compared with the control.

However, no significant differences among the one spray treatments were obtained in both seasons. In addition, in the second season trees sprayed twice in March and May (T10) or in April and May (T11) resulted in a lower fruit drop percent than those sprayed twice in February and March (T6) or in February and April (T7). Garcia *et al.* (1983) found that zinc and manganese foliar sprays decreased fruit drop of Valencia orange trees. Meanwhile, Nakhlla (1998) reported that monthly foliar sprays of zinc 3, 6 or 9 times decreased fruit drop of Navel oranges. Also, Kassem and Marzouk (2004) stated that 1, 2 or 3 zinc foliar spray decreased drop percent of mango fruits.

Yield

The results of both 2005 and 3006 seasons revealed that the yield as weight or number of fruits per tree was markedly increased by all treatments comparing with the control (Table 4). The data also showed that, during both seasons the average yield of trees sprayed once in April (T4) or in May (T5) was significantly higher than that of trees sprayed once in February (T2) or in March (T3). Also, trees sprayed twice in March and May (T10) or April and May (T11) were the best treatments comparing with all other spraying applications. In general, trees received two sprays gave higher yield than those sprayed once. Analogous results on different citrus species were obtained by Garcia *et al.* (1983), El-Shamy *et al.* (1989), Egorashvili *et al.* (1991), Qin *et al.* (1993), Patel *et al.*(1997) and Nakhlla (1998). Moreover, Swiethik (2002) reported that zinc sprays applied before anthesis might be most beneficial in terms of fruit yield in citrus.

Fruit quality

The data in Table 5 showed that trees sprayed once in May (T5) and all the two spray treatments significantly increased fruit TSS in both seasons as compared with the control. Additionally, the highest increment in TSS was noticed by the two sprays treatments in the second season only. On the other hand, fruit acidity, weight, length and diameter were not significantly affected by any of the spraying treatments in both seasons (Table 4). These results are, generally, in line with those of Qin *et al.* (1993), Singh *et al.* (1993), Langthosa and Bhattacharyya (1991), Nakhlla (1998), Torres *et al.* (2002) and Kassem and Marzouk (2004)

Table (4) Effect of Fe, Zn and Mn foliar sprays on fruit set, retention and drop and tree yield of Hindi-Be-Senara mango trees in 2005 and 2006.

Treatments	2005						2006					
	Fruit set (%)	Fruit retention (%)	Fruit drop (%)	Yield (kg/tree)	No. of fruits /tree	Yield* increment (%)	Fruit set (%)	Fruit retention (%)	Fruit drop (%)	Yield (kg/tree)	No. of fruits /tree	Yield* increment (%)
Control (water spray only)	26	23	77	68	313	0.0	20	25	75	57	258	0.0
One spray in February	30	28	72	75	327	10.29	28	31	69	66	286	15.79
One spray in March	35	31	69	77	360	13.23	36	34	66	67	293	17.54
One spray in April	29	35	65	80	367	17.65	25	37	63	72	312	26.32
One spray in May	25	38	62	85	379	25.00	23	38	62	73	319	28.07
Two sprays in February and March	42	38	62	88	373	29.40	35	35	65	75	336	31.58
Two sprays in February and April	37	40	60	93	380	36.76	31	40	60	77	338	35.09
Two sprays in February and May	32	42	60	97	397	42.65	29	42	58	76	361	33.33
Two sprays in March and April	41	40	55	96	406	41.18	38	43	57	74	356	29.82
Two sprays in March and May	36	45	55	98	425	44.12	32	50	50	82	377	43.86
Two sprays in April and May	34	46	54	95	421	39.70	28	48	52	83	375	45.61
L.S.D$_{0.05}$	5	2	11	6	23	-	7	4	8	5	20	-

* Relative percentage of yield increment over control

Table (5): Effect of Fe, Zn and Mn foliar sprays on fruit weight, length, TSS and acidity of Hindi-Be-Senara mango trees in 2005 and 2006.

Treatments	2005					2006				
	TSS (%)	Acidity (%)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	TSS (%)	Acidity (%)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
Control (water spray only)	16.48	0.34	218	12.07	6.82	15.26	0.38	221	12.13	6.28
One spray in February	16.60	0.36	228	11.78	6.63	15.40	0.38	231	11.21	6.42
One spray in March	16.80	0.35	214	11.62	6.21	15.20	0.36	229	12.72	6.24
One spray in April	17.00	0.36	218	12.01	6.76	15.60	0.32	229	12.88	6.36
One spray in May	17.40	0.38	224	11.82	6.80	15.80	0.40	231	12.12	6.28
Two sprays in February and March	17.20	0.40	236	11.66	6.22	16.28	0.38	229	11.82	6.23
Two sprays in February and April	17.60	0.36	245	12.08	7.34	16.42	0.32	223	12.08	6.24
Two sprays in February and May	17.82	0.38	244	11.86	7.25	16.64	0.36	210	11.66	6.02
Two sprays in March and April	17.26	0.40	236	11.80	7.12	16.46	0.40	208	11.86	6.21
Two sprays in March and May	17.60	0.38	231	11.62	6.62	16.60	0.38	218	12.08	6.12
Two sprays in April and May	17.83	0.36	226	11.43	7.13	16.86	0.40	221	12.62	6.21
$L.S.D_{0.05}$	0.66	NS	NS	NS	NS	0.46	NS	NS	NS	NS

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الملخص العربى

إستجابة أشجار المانجو لميعاد وعدد مرات الرش الورقى بالحديد والزنك والمنجنيز المخلبى

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أجريت هذه الدراسة خلال عامى ٢٠٠٥ و ٢٠٠٦ بهدف دراسة مدى استجابة أشجار المانجو صنف هندى بسنارة لميعاد وعدد مرات الرش الورقى بمحلول يحتوى على كل من الحديد والزنك والمنجنيز المخلبى، حيث تم رش الأشجار مرة أو مرتين قبل الإزهار الكامل، وعند الإزهار الكامل، وقبل عقد الثمار، وعند العقد – وكانت النتائج كالتالى:

- وجد أن رشة واحدة قبل العقد يتبعها رشة واحدة عند العقد كانت أفضل معاملة مؤثرة.
- مواعيد الرش قبل الإزهار الكامل وعند العقد، عند الإزهار الكامل وعند العقد، قبل العقد وعند العقد أعطت أفضل النتائج بالنسبة للرش الورقى مرتين.
- أدى الرش بمحلول الحديد والزنك والمنجنيز المخلبى سواء مرة أو مرتين فى أى ميعاد إلى زيادة محتوى الأوراق من المغنسيوم والحديد والزنك والمنجنيز والكلوروفيل، كما أدى إلى زيادة طول الأفرخ خلال موسمى الدراسة.
- بصفة عامة، الرش مرة أو مرتين أدى إلى زيادة معنوية فى عقد وبقاء الثمار والمحصول وإنخفاض نسبة تساقط الثمار.
- أيضاً، أدت معاملات الرش الورقى إلى زيادة محتوى الثمار من المواد الصلبة الذائبة الكلية وفيتامين ج، بينما حموضة وقطر الثمرة لم يتأثرا.