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Foliar Spray of Some Nutrient Elements and Antioxidants for Improving Yield and Fruit Quality of Hindi Mango Trees

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Abstract: Hindi mango trees were treated with some nutrient elements and antioxidants in form of Sowrd as a commercial product which contains K_2O 25%, Mg 0.5%, Zn 0.5%, salicylic acid 25%, L- ascorbic acid 0.01%, Riboflavin 0.01%) as foliar application. Treatments were arranged as follows: (1) Control (spraying with water only). (2) Spraying Sword at 1% once (at full bloom). (3) Spraying Sword at 1% twice (at full bloom and two weeks after fruit set). (4) Spraying Sword at 2% once (at full bloom). (5) Spraying Sword at 2% twice (at full bloom and two weeks after fruit set). Results show that, foliar application of sword had a positive effect on leaf mineral content, yield and fruit quality of Hindi mango trees. Spraying sword at 2% twice at full bloom and two weeks after fruit set is the promising treatment for increasing fruit set, reducing fruit drop, raising fruit retention, maximize the yield and improving fruit physical properties (such as fruit weight, length, circumference, peel and pulp) as well as chemical properties of mango fruits by increasing TSS and reducing acidity.

Key words: Foliar spray · Nutrients · Antioxidants · Fruit quality · Yield · Mango

INTRODUCTION

Mango is one of the important fruit in the tropics and subtropics region. In Egypt, mango considered the most popular fruit and occupies the third place in acreage after citrus and grapes. The area of mango orchards reached 71009 ha producing about 598084 tons of fruits annually [1]. However, poor fruit set is consider as one of the problems that facing mango productivity especially in the new reclaimed lands such trees grow under sandy conditions which produce low yield and fruit quality due to lacking their mineral constituents. Meanwhile, various trials were done to raise fruit set, minimize the percentage of fruit drop, increase tree yield and improve fruit quality by spraying trees with some macro and micronutrients to reach such goal [2]. In this respect, spraying of potassium has a positive effect on fruit setting, retention, yield and fruit quality because it plays an important regulatory role in many physiological and biochemical processes of plant [3-5]. Furthermore, productivity and fruit quality for several cultivars of mango was improved by potassium spray as a result to its role in increasing tolerance to stresses and improving the formation and accumulation of sugars [6, 2, 7]. On the other hand, there are nutrient elements and antioxidants play a great role in increasing fruit set and retention, decreasing fruit drop and improving fruit quality that maximize productivity such as zinc, magnesium, salicylic acid, riboflavin and ascorbic acid. In the past mango growers used synthetic auxins for enhancing production. Nowadays, green cultivation prevents the application of these auxins for protecting our environment from pollution and encourages the application of antioxidants instead of them [8]. Also, antioxidants play an important role in protecting the cell from senescence as well as enhancing the production of organic fruits. They prevent the free radicals produced during plant metabolism from oxidation of lipids, the components of plasma membrane which accompanied with the loss of permeabiliy and the death of cells [9]. Magnesium and zinc have promising effect on plant metabolism. They are responsible for producing the natural auxin (IAA), activating some enzymes, biosynthesis of chlorophylls [10].

Therefore, this research aims to study the effect of foliar application of potassium combined with nutrient elements and antioxidants (zinc, magnesium, salicylic acid, riboflavin and ascorbic acid) on improving fruit set, retention, yield and fruit quality of mango trees.

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MATERIALS AND METHODS

The experiment was carried out during the 2011 and 2012 seasons in a private orchard located at El-Adlia Agricultural Society, Belbis, El-Sharkia Governorate, Egypt. Ten-year-old Hindi mango trees were the materials of this study which grown in sandy soil under drip irrigation system, spaced at 6 x 4 m apart and the selected trees were uniform in vigour and size. All trees received the standard orchard practices and the experiment was designed in a complete randomized block with three replications. Three trees were included per plot. Trees were sprayed with commercial product namely Sword contains the following components: K_2O 25%, magnesium 0.5%, zinc 0.5%, salicylic acid 25%, L - ascorbic acid 0.01%, Riboflavin 0.01% and adjutants and carrier materials 48.98%. The treatments were applied as follows:

T1 = Control (spraying with water only).
T2 = Spraying Sword® at 1% once (at full bloom).
T3 = Spraying Sword® at 1% twice (at full bloom and two weeks after fruit set).
T4 = Spraying Sword® at 2% once (at full bloom).
T5 = Spraying Sword® at 2% twice (at full bloom and two weeks after fruit set).

The spraying was conducted until the run off point with Triton B at 0.1 % as a wetting agent and the following parameters were measured for both seasons:

- Fruit set/panicle was recorded.
- Fruit drop % was calculated using the following equation:

Fruit drop % = (Fruit set - Fruit retention)/ Fruit set x 100

- Fruit retention/panicle was recorded at mature stage (a week before harvest) in both seasons.
- Tree yield was harvested on mid-June in each season, the number of fruits per tree was counted and tree yield was weighted as Kg/tree.
- Fruit Quality: A sample of 10 fruits of each tree was taken at the harvest time to determine the physical and chemical properties i.e. fruit weight (g), length and circumference (cm) as well as fruit pell and pulp weight (g), seed weight (g) and pulp/seed ratio. The total soluble solids percentage (TSS%) was measured using a hand refractometer, while acidity % was determined as citric acid content using fresh juice with titration against 0.1 Na OH. Finally, pulp content of vitamin C was estimated according to A.O.A.C [11].
- Leaf Mineral Content: Macro nutrients were determined in dry leaf samples which collected from each tree at the second week of July in both seasons. N% was measured by Micro-Kjeldahl according to Pregel [12]. Also, P% was determined as described by Champman and Parker [13], while K% was measured according to Brown and Lilleland [14].

Statistical Analysis: Data were analyzed by analysis of variance (ANOVA) and means were compared using Duncan's test at $p< 0.05$ to determine the significance of differences between the conducted treatments [15].

RESULTS AND DISCUSSION

Leaf Area and Mineral Content: Table 1 show that leaf area was significantly affected by different treatments. In this respect, spraying sword at 2% concentration either once or twice recorded higher values comparing with 1% concentration. However, spraying sword at 2% twice (T5) gave the highest significant values in both studied seasons comparing with all other treatments including the control. As for leaf mineral content, data in Table 1 indicated that N content was significantly affected by sword treatments especially at higher concentration (2%) which recorded higher values in the two studied seasons. In this concern, spraying 2% twice gave the maximum N content in the leaves followed by the same concentration when sprayed for one time. This was true in both studied seasons. Concerning P% in the leaves, similar results of nitrogen were obtained, since sword at 2% especially when sprayed twice gave the highest significant values in both studied seasons compared with all other treatments. Regarding K content in the leaves, more or less the same trend of N and P content was observed, where spraying 2% twice of sword gave the highest values followed without significance by the same concentration only one time then 1% twice. The previous observation was detected in the first and second seasons.

Yield and Fruit Physical Properties: Regarding fruit set as well as fruit drop and retention, it's clear from the obtained results in Table 2 that all sword treatments significantly increased fruit set as well as fruit retention and decreased significantly fruit drop during the two seasons. Furthermore, the obtained data took the same

Table 1: Effect of exogenous application of some nutrients elements and antioxidants on growth (leaf area) and leaf mineral content (NPK) of Hindi mango trees during 2011 and 2012 seasons.

	Leaf area (cm^2)		N (%)		P (%)		K (%)	
Treatments	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1= Control	51.8 e	46.6 e	1.36 e	1.52 e	0.15 e	0.16 e	0.77 c	0.78 c
T2= Sword once (1%)	55.6 d	50.0 d	1.48 d	1.66 d	0.18 d	0.20 d	0.96 b	0.98 b
T3= Sword twice (1%)	61.1 c	55.0 c	1.59 c	1.79 c	0.21 c	0.23 c	1.01 a	1.04 a
T4= Sword once (2%)	65.6 b	58.9 b	1.68 b	1.89 b	0.25 b	0.28 b	1.03 a	1.06 a
T5= Sword twice (2%)	68.3 a	61.4 a	1.84 a	2.06 a	0.29 a	0.32 a	1.04 a	1.06 a

Means within a column followed by different letter (s) are statistically different at 5 % level.

Table 2: Effect of exogenous application of some nutrients elements and antioxidants on fruit setting as well as fruit drop and retention of Hindi mango trees during 2011 and 2012 seasons.

	No. fruit set /panicle		Fruit drop (%)		Fruit retention /panicle	
Treatments	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1= Control	5.0 c	5.5 c	37.7 a	35.4 a	3.1 d	3.5 d
T2= Sword once (1%)	11.5 b	12.7 b	29.1 b	27.3 b	8.2 c	9.2 c
T3= Sword twice (1%)	12.0 b	13.2 b	23.8 c	22.4 c	9.1 c	10.2 c
T4= Sword once (2%)	14.3 a	15.6 a	19.0 d	17.9 d	10.8 b	12.5 b
T5= Sword twice (2%)	15.0 a	16.7 a	13.3 e	12.8 e	13.0 a	14.6 a

Means within a column followed by different letter (s) are statistically different at 5 % level.

Table 3: Effect of exogenous application of some nutrients elements and antioxidants on yield and some fruit physical properties of Hindi mango trees during 2011 and 2012 seasons.

	No. of fruits/tree		Yield (kg/tree)		Fruit weight (g)		Fruit length (cm)		Fruit circumference (cm)	
Treatments	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1= Control	125e	138e	15.6e	16.5e	124.4d	119.4e	9.3b	9.2c	13.2d	13.0b
T2= Sword once (1%)	153d	168d	26.5d	27.7d	173.0c	165.0c	11.5a	11.0b	17.3bc	17.2b
T3= Sword twice (1%)	171c	188c	28.9c	29.4c	169.2c	156.4d	11.7a	11.3b	16.5c	17.2b
T4= Sword once (2%)	187b	205b	37.6b	41.1b	201.0b	200.4b	12.3a	12.2ab	18.0ab	18.5a
T5= Sword twice (2%)	198a	218a	43.5a	50.1a	219.7a	229.6a	12.5a	13.3a	19.0a	18.5a

Means within a column followed by different letter (s) are statistically different at 5 % level.

trend, since spraying sword at both concentrations achieved higher number of fruit set or fruit retention per panicle and also reduced the percentage of fruit drop than the control in both studied seasons. In this respect, spraying sword at 2% recorded the maximum significant fruit set in compare with spraying 1% and the control. While, 2% of sword sprayed twice (at full bloom and two weeks after fruit set) gave higher number of fruit retention per panicle and reduced the percentage of fruit drop comparing with the other treatments including the control in both seasons. Therefore, 2% of sword sprayed twice gave the best results for fruit yield production. As for yield and fruit physical properties, data presented in Table 3 showed that yield as number of fruits or kg/tree was affected significantly by sword treatments. However, results of both parameters took the same trend, since spraying sword at both concentrations gave higher values for yield as number of fruits or kg per tree in both studied seasons. In this respect, 2% of sword sprayed twice recorded the maximum significant yield in compare with all other treatments including the control. On the other side, 2% of sword sprayed twice achieved about 279 and 304% as an increment in the yield compared with the control (in the first and second seasons, respectively). In the second order, 2% of sword sprayed once recorded 241 and 249 % than the control (in the first and second seasons, respectively). However, 1% of sword sprayed twice gave 185 and 178% over the control, while 1% of sword sprayed once gave 170 and 168 (in the first and second seasons, respectively).

Concerning fruit physical properties, data in Table 3 revealed that fruit weight, fruit length and fruit circumference were significantly affected by sword treatments especially the high concentration (2%) which gave higher values for all the above mentioned parameters. However, the highest significant value of fruit weight was recorded when sword sprayed at 2% twice followed by the same concentration sprayed

Table 4: Effect of exogenous application of some nutrients elements and antioxidants on some fruit physical properties of Hindi mango trees during 2011 and 2012 seasons.

	Pell weight (g)		Pulp weight (g)		Seed weight (g)		Pulp/seed ratio	
Treatments	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1= Control	22.2c	19.4c	75.4c	57.8c	22.0b	19.3c	3.43a	2.99a
T2= Sword once (1%)	28.5bc	27.3bc	117.8b	99.4ab	25.1ab	27.6ab	4.69a	3.60a
T3= Sword twice (1%)	29.4bc	25.8bc	118.7b	92.8b	28.4ab	24.0bc	4.18a	3.87a
T4= Sword once (2%)	30.6b	30.7b	109.1b	130.1a	26.6ab	31.2a	4.10a	4.17a
T5= Sword twice (2%)	39.8a	43.4a	153.5a	127.0a	33.0a	30.9ab	4.65a	4.11 a

Means within a column followed by different letter (s) are statistically different at 5 % level.

Table 5: Effect of exogenous application of some nutrients elements and antioxidants on some fruit chemical properties of Hindi mango trees during 2011 and 2012 seasons.

	T.S.S(%)		Acidity (%)		T.S.S/acid Ratio		Ascorbic acid (mg/100 ml juice)	
Treatments	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1= Control	13.3c	11.9c	0.55a	0.45a	24.2b	26.4b	38.4d	40.4d
T2= Sword once (1%)	16.4b	15.8b	0.22b	0.19b	74.5a	83.2a	41.3c	43.4c
T3= Sword twice (1%)	16.3b	15.1b	0.22b	0.23b	74.1a	65.7a	42.3bc	44.5bc
T4= Sword once (2%)	16.2b	17.7a	0.20b	0.20b	81.0a	88.5a	43.4ab	45.5ab
T5= Sword twice (2%)	19.5a	19.1a	0.19b	0.19b	102.6a	100.5a	44.8a	47.0a

Means within a column followed by different letter (s) are statistically different at 5 % level.

for one time in the two studied seasons. While, for fruit length, all sword treatments significantly increased this parameter than the control, but the significance was lacked among the sword treatments, this observation was only in the first season, while in the second one, spraying sword at 2% twice gave the highest fruit length value followed by the same concentration sprayed for only one time. Concerning fruit circumference, 2% sword sprayed once or twice recorded maximum significant values during the two studied seasons.

Physical Properties: Data in Table 4 showed that peel weight was increased significantly by sword treatments especially with the high ratio content (2%). In this concern spraying sword at 2% twice recorded the heaviest peel weight followed by 2% once then 1% twice and finally 1% once, while the untreated trees (control) gave the lowest peel weight. As for pulp weight, it is clear from the obtained results in Table 4 that sword treatments at any concentration significantly increased pulp weight than the control, since spraying 2% sword twice gave the heaviest pulp (153 g) in the first season, while in the second season, concentration of 2% once recorded the higher pulp weight (130 g) followed without significance by spraying the same concentration twice (127 g). Regarding seed weight, result indicated that both sword concentration increased seed weight than the control. This increment was significant with the high concentration only when sprayed twice. This was true in the first season, while in the second one, spraying 2% sword for one time gave the highest seed weight, followed without significance by 2% twice then the 1% once. Concerning pulp/seed ratio, no significant differences were detected among different sword treatments, although 2% concentration sprayed twice recorded the highest ratio in the first season, while the same concentration sprayed once gave the highest ratio in the second season.

Chemical Properties: Results in Table 5 revealed that TSS% was significantly increased by sword treatments than the control in both studied seasons. In this respect, spraying the high concentration twice gave the highest TSS content (19.5 and 19.1 %) in the first and second seasons, respectively. As for acidity percentage, all sword treatments significantly reduced acidity % than the control. On the other hand, acidity value among sword treatments lacked significance. Concerning TSS/acid ratio, all sword concentrations significantly increased this parameter comparing with the control. In this respect, no significant differences were detected among the sword treatments. Regarding vitamin C content in fruit juice, it's clear that sword sprayed at 2% either once or twice significantly increased V.C. value than the control and the trees sprayed twice recorded the highest value.

From the abovementioned results, it is evident that spraying sword (K_2O 25%, Mg 0.5%, Zn 0.5%, salicylic acid 25%, L- ascorbic acid 0.01%, Riboflavin 0.01%) improved tree growth (as leaf area) and raised leaf mineral content of NPK. Moreover, leaf content of N and P were increased by increasing sword concentration and number of application. The results are in agreement with those reported by Ibrahim *et al.* [8] and Ali [16] who found that

foliar application of nutrients (K, Zn, Mg) with antioxidants was favorable in enhancing the leaf area and its content of N, P and K than using nutrients and antioxidants alone. Also, the results of Ahmed *et al.* [17] and Morsy and El-Bana [18] who worked on antioxidants are in harmony with the present results. Concerning the effect of nutrients element on leaf mineral content, the results are in parallel with those of Ebeed and Abd El-Migeed [2] and Saleh and Abd El-Monem [6] who reported that N and K leaf content of in 'Fagri Kalan' mango cultivar increased by potassium spray. Bahadur *et al.* [19] found that leaf nutrient status of NPK was raised by Zn foliar spray. Moreover, it is clear that sword has a positive effect on increasing fruit set when applied at full bloom especially at high concentration (2%) and when applied twice (at full bloom and two weeks after fruit set) increased fruit retention by decreasing fruit drop percentage. This explains the significant deference between treatments concerning the yield as number of fruits per tree as well as yield weight due to improves fruit weight by all sword treatments. Furthermore, spraying sword at both concentrations improved fruit physical properties (fruit weight, length, circumference, peel and pulp) and chemical properties of mango fruits by increasing TSS and reducing acidity. Generally, increasing fruit set, retention, decreasing fruit drop, improving yield and fruit quality may be due to the positive effect of sword on improving the nutritional status of trees. Also, due to its effect on increasing the endogens auxin by its components of some antioxidants and micro nutrients. The previous result are confirmed by many researches reported that spraying mango trees with potassium, some micro elements and antioxidants increased fruit set, fruit retention, reduced fruit drop, also maximized the productivity and improved the fruit quality [2-6, 8, 16, 20-26]. The previous beneficial effects of sword nutrients element (K, Mg, Zn, salicylic acid, ascorbic acid and Riboflavin) on productivity and fruit quality of Hindi Mango were attributed to its positive action on biosynthesis IAA and activating the enzymes, the biosynthesis of chlorophlls and carbohydrates [10]. As well as, the important role of antioxidants is preventing the free radicals which caused the oxidation during plant metabolism. Therefore, they protect the plant cell from senescence [9]. This could be explaining the previous results.

As a conclusion, foliar application of sword (K_2O 25%, Mg 0.5%, Zn 0.5%, salicylic acid 25%, L- ascorbic acid 0.01%, Riboflavin 0.01%) had a positive effect on leaf mineral content, yield and fruit quality of Hindi mango trees. Spraying sword at 2% twice at full bloom and two weeks after fruit set is the promising treatment for increasing fruit set, reducing fruit drop, raising fruit retention, maximize the yield and improving fruit physical properties (such as fruit weight, length, circumference, peel and pulp) as well as chemical properties of mango fruits by increasing TSS and reducing acidity.

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