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Effect of different forms of potassium on growth, yield and fruit quality of mango cv. Hindi

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Abstract: This study was carried out during two successive seasons of 2013 and 2014 on "Hindi" mango trees grown in sandy soil under drip irrigation system in National Research Centre, Researches and Production Station at El-Nobaria- Behaira Government, Egypt, to study the effect of different potassium forms application i.e. potassium citrate, potassium nitrate, mono-potassium phosphate and di- potassium phosphate at two concentrations (1 and 2 %) as a foliar spray for four times at full bloom, after fruit set, during fruit growing (one month ago from fruit set) and before the harvesting (one month from the third spray) on leaves minerals content**,** vegetative growth, yield as well as some physical and chemical characteristics of the fruits. Results showed that spraying Hindi mango trees four times at full bloom, after fruit set, during fruit growing and before the harvesting with 2 % mono potassium phosphate, 2 % di-potassium phosphate and 2 % potassium nitrate were very effective in improving fruit retention, yield as number of fruits or weight (kg/tree) and increased fruit weight and pulp weight and enhanced total soluble solids (TSS) percentage, total sugars and ascorbic acid content. In addition, it reduced fruit acidity content comparing with the control. Also, spraying mango trees with 2 % mono potassium phosphate, 2 % di-potassium phosphate and 2 % potassium nitrate improved the vegetative parameters and nitrogen, phosphorus and potassium contents in the leaves.

Keywords: Mango cv. Hindi, potassium forms, vegetative growth, yield, fruit quality.

Introduction

Mango (*Mangifera indica* L.), one of the most important tropical and subtropical fruit regions of the world. The mango had a great economic importance, it may be eaten fresh or juice or may add in some food industries because it is lucrative, tasty and rich in vitamins and minerals. In Egypt, mango is considered as one of the main fruits. The area of mango orchards reached 241101 feddans, producing about 712537 tons of fruits annually[1].

As is well known the importance of potassium fertilization of mango trees, potassium major elements, which plays an important role in plants and significantly influence on many human-health related quality compounds in fruits and vegetables[2]**.** It is involved in numerous biochemical and physiological processes vital to plant growth, yield, quality and stress[3,4]. It resulted also in improving the fruit quality parameters i.e. total soluble solids, total sugars and coloration[5,6]. These effects might be dedicated to the potassium role in increasing tolerance to stresses and improving the formation and accumulation rates of sugars[7,8].

In this concern[5] indicated that, foliar spray of different forms of potassium improved final fruit yield and net income. The 1 % potassium as K_2SO_4 form was most profitable. Yield, quality, and economic traits all suggest the advantages from applying 1 % K_2SO_4.

Enhancement of mango productivity as a result of potassium application. It also resulted in improving the fruit quality of mango in term of weight, TSS percentage and total sugars[9].

Spraying mango trees with potassium citrate at 0.3 % was the promising treatment, since it improved yield, fruit quality as well as leaf mineral contents comparing with the control[10].

Also, Potassium citrate at (1263 and 1895 g/tree) and mono potassium phosphate at (2000 g/tree) were effective to increase leaf area and improve leaf mineral content. In addition, potassium citrate at (1895 g/tree) and potassium carbonate at (850 g/tree) were very positive in enhancing yield and improved fruit quality as well as physical and chemical properties[11]. Also, the application of K_2SO_4 improved fruit quality (i.e. total soluble solids, total sugar, and ascorbic acid) of guava (cv. Sardar) [5].

Therefore, the aim of the current study is to investigate the effect of different forms of potassium on vegetative growth, leaf mineral content, yield as well as fruit quality of Hindi mango trees grown under sandy soil conditions.

Materials and Methods

This study was carried out during two successive seasons of 2013 and 2014 on mango trees cv. "Hindi" in National Research Centre, Researches and Production Station at El-Nobaria – Behaira Government, Egypt,, to study the effect of some potassium forms such as potassium citrate, mono and di-potassium phosphate and potassium nitrate on vegetative growth, flowering, yield, fruit quality as well as leaf chemical composition of mango cv. Hindi. The study was conducted on ten years old of mango trees cv. "Hindi" planted at 5X5 m apart in a sandy soil under drip irrigation system. The selected trees were uniform in vigor and size. All trees received the standard horticultural practices that carried out in the mango orchards except potassium fertilization. The experiment was designed in a complete randomized block with nine treatments each treatment contains three replicates each replicate was represented by three trees. The treatments were as follows:

1- Control (spraying with water only)

2- Potassium citrate at 1%

3- Potassium citrate at 2 %

4- Potassium nitrate at 1%

5- Potassium nitrate at 2 %

6- Mono-potassium phosphate at 1%

7- Mono-potassium phosphate at 2 %

8- Di-potassium phosphate at 1%

9- Di-potassium phosphate at 2 %

Triton B at 0.1 % as a wetting agent was added to all treatments besides control.

All trees under the study were sprayed four times at full bloom, after fruit set, during fruit growing (one month ago from fruit set) and before the harvesting (one month from the third spray).

The following parameters were measured for both seasons as follows:

1. **Fruit retention/panicle:** was recorded at mature stage (a week before harvest).

2. **Tree yield:** at harvest time (first week of August) in each season, the number of fruits per tree was counted and fruit yield/tree was weighted as Kg/tree.

3. **Fruit physical and chemical parameters:** samples of randomly mature fruits from each replicate were used for measuring various fruit physical and chemical parameters assessed such as: fruit weight (g), weights of pulp, peel and seed (g), total soluble solids (TSS) percentage using a hand refractmeter, total acidity percentage as citric acid, total sugar content as (g/100 g fresh weight), vitamin C content as (mg/100g F.W.) according to **[12].**

4. **Vegetative growth parameters:** at the second week of July in both seasons shoot length, numbers of leaves\shoot, leaf dry weight and leaf area were recorded.

5. **Leaf mineral contents:** Leaves sample were picked from the 3rd and 4th node below panicle at the second week of July in both seasons. The samples were washed, dried, grounded and digested according to [13]. 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 [14].

b. **Phosphorus** was estimated colorimetrically by the stannous chloride method as percentage according to [15].

c. Potassium content was determined by Flame photometer as percentage according to method of [16].

Statistical Analysis

The obtained data was subjected to analysis of variances (ANOVA) according to [17]. Least significant differences LSD were used to compare between means of treatments at probability of 5 %.

Results and Discussions

1. Effect of different potassium forms on fruit retention, number of fruit/tree, yield (Kg/tree) and fruit weight of mango cv. Hindi

Data in Table (1) revealed that all examined potassium forms treatments significantly increased fruit retention percentage, fruits number/tree and trees yield as compared with untreated trees (control) in both seasons. Anyway, that there was a positive relationship between fruit retention percentage, fruits number/tree and trees yield and potassium levels. Hence, as the level of potassium increased the fruit retention percentage, number of fruits/tree and trees yield increased up to the maximum increasing at the high level of potassium in both seasons. However, the highest fruit retention percentage, number of fruits/tree as well as the greatest tree yield were recorded in both seasons by the trees that spayed with 2 % mono potassium phosphate followed in descending order by those treated with 2% di-potassium phosphate. However, the lowest fruit retention percentage, number of fruits/tree and tree yield were observed with untreated trees (control) in both seasons.

The role of potassium treatments in increasing fruit retention percentage, number of fruits/tree as well as the greatest tree yield may be due to the catalytic factor of the potassium for many biological processes within trees which reflect on the nutritional status of the trees.

Table 1. Effect of different potassium forms on fruits number/tree, yield (kg /tree) and fruit weight of mango cv. Hindi during 2013 and 2014 seasons.

Treatment	Fruit retention (%)		No. fruits/tree		Tree yield (kg/tree)	
	1st	2nd	1st	2nd	1st	2nd
Control (spraying with water only)	0.56	0.60	192.2	163.4	24.9	21.5
Potassium citrate at 1%	0.70	0.88	208.3	182.7	37.5	35.6
Potassium citrate at 2 %	1.29	1.35	216.7	186.4	40.1	38.2
Potassium nitrate at 1%	1.05	1.12	211.1	192.4	40.9	38.4
Potassium nitrate at 2 %	1.70	1.81	229.7	198.3	42.2	36.8
Mono-potassium phosphate at 1%	1.53	1.75	225.9	199.4	42.7	40.1
Mono-potassium phosphate at 2 %	1.83	1.95	242.8	218.3	47.1	42.3
Di-potassium phosphate at 1%	0.80	0.95	208.4	207.3	39.5	41.0
Di-potassium phosphate at 2 %	1.78	1.83	236.9	212.9	45.7	42.4
LSD at 5%	**0.09**	**0.07**	**14.21**	**16.95**	**9.24**	**11.44**

The obtained results are in a harmony with [18, 10, 5, 19,11]. They reported that, spraying mango trees with potassium led to an increment in the fruits number per tree, thereby increasing the yield of the tree and reached to the maximum productivity**.**

2. Effect of different potassium forms on some fruit physical properties of mango cv. Hindi

Data in Table (2) reported that all examined potassium forms treatments improved fruit physical properties of mango cv. Hindi i. e, fruit weight, pulp weight, peel weight and seed weight as compared with

control tree in the two seasons. However, the highest values of fruit weight, pulp weight, peel weight and seed weight were scored by 2% potassium nitrate-sprayed trees. This trend was true only in the first season, while in the second one the picture was completely changed, where 2% potassium citrate-sprayed trees showed its superiority in this concern. On contrary, the lowest values of these parameters were recorded by control trees in both seasons.

The importance of potassium in improving fruit may be due to its function in promoting synthesis of photosynthates and their transport to fruit. Also, the effect of potassium on fruit quality can be also indirect as a result of its positive interaction with other nutrients especially with nitrogen and production practices[2]. The present results are in accordance with those of [10, 5, 9, 19, 11]. They reported that potassium application improved fruit quality of mango.

Table 2. Effect of different potassium forms on some physical fruit properties of mango cv. Hindi during 2013 and 2014 seasons.

Treatment	Fruit weight (g)		Pulp weight (g)		Peel weight (g)		Seed weight (g)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control (spraying with water only)	129.57	131.58	81.89	83.16	28.25	28.68	19.44	19.74
Potassium citrate at 1%	180.30	194.85	113.78	123.15	39.25	42.48	27.00	29.23
Potassium citrate at 2 %	185.05	204.94	116.95	129.52	40.34	44.68	27.76	30.74
Potassium nitrate at 1%	189.02	201.10	119.46	127.10	41.21	43.84	28.35	30.17
Potassium nitrate at 2 %	193.99	193.77	122.60	122.46	42.29	42.24	29.10	29.07
Mono-potassium phosphate at 1%	189.54	197.78	119.79	125.00	41.32	43.12	28.43	29.67
Mono-potassium phosphate at 2 %	192.91	199.15	121.92	125.83	42.05	43.42	28.94	29.87
Di-potassium phosphate at 1%	193.75	199.58	122.45	126.14	42.24	43.51	29.06	29.94
Di-potassium phosphate at 2 %	183.72	185.58	116.11	117.28	40.05	40.46	27.56	27.84
LSD at 5%	**6.98**	**4.31**	**5.09**	**3.42**	**2.83**	**3.43**	**3.21**	**3.43**

3. Effect of different potassium forms on some fruit chemical properties of mango cv. Hindi

The results shown in Table (3) illustrated that, all studied potassium forms treatments improved fruit chemical properties of Hindi mango *i.e.* total soluble solids (TSS) percentage, total acidity percentage, total sugars and ascorbic acid content as compared with control in both seasons. However, the highest values of fruit TSS content in the first season were gained by 2 % potassium citrate, followed by 1 % potassium citrate, while in the second seasons 2 % di-potassium phosphate and 2 % mono potassium phosphate showed its superiorities in this concern. Concerning fruit total acidity it's obvious that, spraying mango trees with 2 % mono and di potassium phosphate reducing the fruit content of total acidity in both seasons in comparison with other treatments, while, the control in the first season in addition to 1 % potassium citrate and 1 % di-potassium phosphate in the second one recorded the highest values of this concern

Moreover, 2 % di-potassium phosphate, 1 % di-potassium phosphate and 2% mono potassium phosphate exhibited to be the most promising treatments for inducing the highest values of fruit total sugars content in both seasons. Additionally, in the first season 2% potassium citrate induced the greatest fruit ascorbic acid content, followed in descending order by 2% di-potassium phosphate and 1% potassium citrate, while in the second season 2% mono potassium phosphate, 2% di-potassium phosphate and 1% mono potassium phosphate showed its superiority in this regard.

The role of potassium in improving fruit chemical properties could be attributed to the potassium role in improving the formation and accumulation rates of sugars [7, 8].

Table 3. Effect of different potassium forms on some chemical fruit properties of mango cv. Hindi during 2013 and 2014 seasons.

Treatment	Total soluble solids TSS (%)		Total acidity (%)		Total sugar (g/100 g fresh weight)		Ascorbic acid (mg/100 ml juice)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control (spraying with water only)	15.14	16.35	0.55	0.66	11.94	12.71	38.12	41.02
Potassium citrate at 1%	17.92	17.28	0.50	0.65	13.21	14.93	43.12	43.26
Potassium citrate at 2 %	18.14	18.11	0.47	0.58	14.34	15.63	45.30	46.24
Potassium nitrate at 1%	15.19	17.80	0.50	0.59	13.92	14.82	38.46	41.10
Potassium nitrate at 2 %	15.37	18.33	0.35	0.53	14.14	15.34	39.97	40.92
Mono-potassium phosphate at 1%	16.94	17.93	0.38	0.55	14.92	15.52	40.17	47.22
Mono-potassium phosphate at 2 %	17.23	19.46	0.32	0.36	15.60	16.10	40.64	48.50
Di-potassium phosphate at 1%	16.78	18.94	0.52	0.63	15.93	16.29	41.92	42.63
Di-potassium phosphate at 2 %	16.14	20.14	0.35	0.39	16.14	17.38	43.21	47.39
LSD at 5%	**1.35**	**1.94**	**0.16**	**0.15**	**1.25**	**1.70**	**3.92**	**2.16**

Similar finding were achieved by [10, 5, 9, 19, 11]. They found that potassium improved fruit chemical properties as TSS, total acidity and vitamin C of mango fruits. In addition, [20] found that potassium have significant influence on fruit chemical properties through its influence on soluble solids, acidity and vitamin C content.

4. Effect of different potassium forms on some vegetative growth measurements of mango cv. Hindi

Results in Table (4) indicated that, all tested potassium forms succeeded in increasing vegetative growth measurements of mango cv. Hindi when compared with untreated trees (control) in both seasons. On the other hand, there was a positive correlation between the values of length of terminals shoot, leaves number, leaf area and leaf dry weight and the concentration of potassium, so the values of vegetative growth measurements increased as the concentration of potassium increased.

Table 4. Effect of different potassium forms on some vegetative growth measurements of mango cv. Hindi during 2013 and 2014 seasons.

Treatment	Shoot length		No. leaves/shoot		Leaf area		Leaf dry weight	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control (spraying with water only)	32.14	30.76	21.34	24.63	73.89	71.62	0.71	0.70
Potassium citrate at 1%	34.80	36.28	28.14	31.04	76.39	72.39	0.72	0.75
Potassium citrate at 2 %	36.14	37.24	29.46	32.51	78.30	72.84	0.75	0.76
Potassium nitrate at 1%	41.93	40.37	25.21	25.60	79.36	77.93	0.75	0.80
Potassium nitrate at 2 %	43.51	42.30	26.13	25.92	81.43	78.34	0.77	0.81
Mono-potassium phosphate at 1%	35.94	36.14	22.09	29.16	77.21	74.36	0.75	0.77
Mono-potassium phosphate at 2 %	38.14	39.18	23.64	30.26	78.21	75.46	0.74	0.78
Di-potassium phosphate at 1%	36.72	37.14	27.40	28.18	79.11	76.24	0.75	0.79
Di-potassium phosphate at 2 %	39.21	38.01	27.93	29.37	79.47	77.24	0.76	0.81
LSD at 5%	**2.17**	**3.29**	**1.40**	**1.62**	**4.61**	**3.42**	**0.023**	**0.046**

This trend was true in both seasons of the study. However, the highest values of terminal shoot length (43.51 and 42.30 cm), leaf area (81.43 and 78.34 cm^2), and leaf dry weight (0.77 and 0.81 g.) were recorded

by 2% potassium nitrate, followed in descending order by 1% potassium nitrate in the first and second seasons, respectively. The differences between the two abovementioned treatments were non-significant in both seasons. Moreover, 2 % potassium citrate showed to be the most effective treatment for inducing the highest number of leaves/shoot as it scored 29.46 and 32.51 in the first and second seasons, respectively.

5. Effect of different potassium forms on leaf contents of N, P and K of mango cv. Hindi

Results in Table (5) revealed that, all tested potassium forms treatments increased the values of leaf contents of N, P and K as compared with untreated trees in both seasons. However, the highest leaf nitrogen content was recorded by 1.5 % potassium nitrate, followed in descending order by 1 % potassium nitrate in both seasons.

Whereas, the highest value of leaf phosphorous content was scored by 2% mono potassium phosphate, followed by 2% di-potassium phosphate in both seasons. While, the values of leaf potassium content was registered by 2% di-potassium phosphate, followed in descending order by 1 % di-potassium phosphate and 2% mono potassium phosphate in both seasons of the study.

Table 5. Effect of different potassium forms on leaf contents of N, P and K of mango cv. Hindi during 2013 and 2014 seasons.

	N%		P%		K%	
Treatment	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
Control (spraying with water only)	2.03	2.14	0.194	0.191	2.14	2.07
Potassium citrate at 1%	2.36	2.39	0.216	0.210	2.54	2.59
Potassium citrate at 2 %	2.49	2.47	0.219	0.221	2.67	2.64
Potassium nitrate at 1%	2.69	2.74	0.201	0.211	2.31	2.43
Potassium nitrate at 2 %	2.73	2.81	0.208	0.217	2.39	2.49
Mono-potassium phosphate at 1%	2.53	2.41	0.228	0.222	2.59	2.69
Mono-potassium phosphate at 2 %	2.64	2.48	0.247	0.229	2.76	2.73
Di-potassium phosphate at 1%	2.43	2.59	0.216	0.220	2.87	2.79
Di-potassium phosphate at 2 %	2.47	2.63	0.237	0.221	2.94	2.85
LSD at 5%	**0.21**	**0.24**	**0.021**	**0.017**	**0.14**	**0.29**

The results, concerning the influence of different potassium forms on vegetative growth and leaf mineral contents, are in a harmony with those reported by [10, 5, 19, 11] as spraying mango trees with potassium improved tree growth and raised leaf mineral content of N, P and K.

Conclusions

From the previous results it could be concluded that, all potassium forms had a positive effect on trees yield, fruit physical and chemical properties as well as leaves contents of nitrogen, phosphor and potassium as compared with control of mango cv. Hindi. 2% mono potassium phosphate, 2% di-potassium phosphate and 2% potassium nitrate were the best treatments to enhance the fruit yield, fruit physical and chemical properties, vegetative growth as well as leaves contents of nitrogen, phosphorus and potassium**.**

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