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Effect of Different Potassium Fertilizer Forms on Yield, Fruit Quality and Leaf Mineral Content of Zebda Mango Trees

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Abstract: This experiment was carried out during 2011 and 2012 seasons on adult Zebda mango trees 18 years old grown in loamy sandy soil under basin irrigation system in a private farm at El-Sadat district, Minufiya governorate, Egypt, to study the effect of different potassium forms application i.e. feldspar (4800 & 7200 g/tree), potassium carbonate (850 &1275 g/tree), potassium citrate (1263 &1895 g/tree) and mono potassium phosphate (1333 &2000 g/tree) on leaf area and mineral content, yield as number of fruits or Kg/tree, fruit physical and chemical properties. Each potassium form was applied in two equal doses; the first rate was added at the second week of Feb. and the second rate was added at the first week of June. Results indicated that all different potassium forms application had a positive effect on leaf area, mineral content, yield and fruit physical and chemical characteristics as comparing with control. Potassium citrate at (1263 & 1895 g/tree) and mono potassium phosphate at (2000 g/tree) were the best treatments 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 the most effective treatments in enhancing yield and improved fruit quality as well as physical and chemical properties.

Key words: Mango · Potassium · Leaf mineral content · Yield · Fruit quality

INTRODUCTION

Mango (*Mangifera indica* L.) considered the king of fruit in plenty of the countries world wide. Mango is regarded in Egypt as one of the major local fruit crops and approximately could be considered the third fruit crop after citrus and grapes. However, mango fruits are considered as one of the most popular fruits for the Egyptian consumer due to its good flavor, delicious taste, nutritive value and other fruit attractive features. It is in need to be of wide spreading in A.R.E. particularly in the new reclaimed areas. Mangoes cultivation extended rapidly in Egypt to reach (240804) feddans producing (786528) tons and average production/feddan is (4.29) tons according to Ministry of Agriculture [1]. It is well known that many problems face and affect mango productivity i.e. poor fruit set and high fruit drop percentage at different fruit growth stages especially in the new reclaimed lands. Such trees grow under sandy soil conditions are poorly yielded with low fruit quality due to lacking their mineral constituents [2]. Productivity of several mango cultivars was improved by potassium spray [3]. It resulted also in improving the fruit quality parameters i.e., TSS%, total sugars and coloration [4, 5]. These effects might be dedicated to the potassium role in increasing tolerance to stresses and improving the formation and accumulation rates of sugars [6, 7]. Potassium is an essential plant mineral element (nutrient) having a significant influence on many human-health related quality compounds in fruits and vegetables [8]. Although K is not a constituent of any organic molecule or plant structure, it is involved in numerous biochemical and physiological processes vital to plant growth, yield, quality and stress [9, 10]. In addition to stomatal

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regulation of transpiration and photosynthesis, K is also involved in photophosphorylation, transportation of photoassimilates from source tissues via the phloem to sink tissues, enzyme activation, turgor maintenance and stress tolerance [8, 9, 11]. Adequate K nutrition has also been associated with increased yields, fruit size, increased soluble solids and ascorbic acid concentrations, improved fruit color, increased shelf life and shipping quality of many horticultural crops [12-16]. Potassium is one of the essential nutrients for plant growth and vital for sustaining high-yield in agriculture. Potassium is often referred as the quality element for crop production [8]. The crucial importance of potassium in quality formation stems from its role in promoting synthesis of photosynthates and their transport to fruits. With a shortage of potassium, many metabolic processes are affected like the rate of photosynthesis, the rate of translocation and enzyme systems [9]. The scope of the currant investigation is to find out the effect of different application forms of potassium on leaf mineral content, productivity and fruit quality of Zebda mango trees grown under loamy sandy soil conditions.

MATERIALS AND METHODS

This study was carried out during two successive seasons (2011 and 2012) on 18 years old Zebda mango trees grafted onto seedling rootstock and planted at 7* 7 meters apart in loamy sandy soil under basin irrigation system at private farm at El–Sadat district, Minufiya government. The physical and chemical properties of the experimental soil are presented in Table (1). The selected trees were uniform in vigor as possible. Fertilization program and other agricultural practices were the same for all trees. The complete randomized block design was used, while each of the following treatments was replicated three times using one tree/plot. The selected trees were subjected to 9 treatments as follows:

- The Control (1000 g per tree potassium sulphate).
- T1: Feldspar at rate 4800 g per tree.
- T2: Feldspar at rate 7200 g per tree.
- T3: Potassium carbonate at rate 850 g per tree.
- T4: Potassium carbonate at rate 1275 g per tree.
- T5: Potassium citrate at rate 1263 g per tree.
- T6: Potassium citrate at rate 1895 g per tree.
- T7: Mono potassium phosphate at rate 1333 g per tree.
- T8: Mono potassium phosphate at rate 2000 g per tree.

Treatments included four sources of potassium fertilization i.e. feldspar, potassium carbonate, potassium citrate and mono potassium phosphate. Each potassium form was applied in two equal doses; the first rate was added at the second week of Feb. and the second rate was added at the first week of June. The (*Bacillus circulans*) bacteria was applied as constant rate of 1000 ml per tree, as a potassium dissolving, after fertilization treatments of Feldspar and irrigation was conducted after the addition of fertilization in both seasons. The experiment was set in a completely randomized block design with three replicates, each consisted of one tree and the following parameters were measured for both seasons as follows:

Leaf Area and its Mineral Content: leaf area was recorded in 1st week of Sept. according to Ahmed and El-Morsy [17] in leaves of spring growth cycle. Leaf samples were collected for chemical analysis in early August of both seasons. Each sample consisted of 30 leaves/tree. Leaves were washed several times with tap water, rinsed with distilled water and then dried at 70°C until a constant weight, ground and digested according to Chapman and Pratt [18]. Nitrogen, phosphorus, potassium and magnesium were determined using the method outlined by Wilde *et al*. [19] as mg/g dry weight.

Yield (as number of fruits and Kg/tree): In each season, at harvest time, the numbers of fruits per tree were counted for each treatment. Tree yield in kilograms was estimated by multiplying number of fruits per tree and average fruit weight for each treatment.

Table 1: Physical and chemical properties of the tested soil

		Particle size distribution%						Macronutrients%			
Sand	Silt	Clay	Texture class					N		P	
85	10	5	Loamy sand					0.06		0.55	
				Soluble cations, meq/L				Soluble anions, meq/L			
pH 1:2.5	EC dS/m	OM%	$CaCO_3$%	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3	HCO_3^{-}	SO_4	Cl^{-}
8.3	0.7	1.5	2.75	2.24	1.45	3.16	0.15	0.00	2.30	1.24	3.46

Fruit Physical and Chemical Parameters: Fruits were harvested at maturity stage (the first week of Sept.) from each tree of various replicates and treatments. Samples of 10 randomly mature fruits from each experimental unit were used for measuring various fruit physical and chemical parameters assessed as: fruit weight (g), fruit volume (cm^3) fruit length and width (cm) fruit shape index (L/D), pulp\fruit ratio, fruit firmness (Ib /$inch^2$) using pressure tester, juice total soluble solids (TSS%) using a hand refractmeter, juice total acidity percentage as citric acid, juice total soluble solids (TSS%)/total acidity ratio, vitamin C (mg/100g F.W.) according to A.O.A.C. [20].

Statistical Analysis: The attained data were tabulated and statistically analyzed according to Snedecor and Cochran [21]. The mean values were compared by LSD at 5% level of probability.

RESULTS

Leaf area (cm^2) and its contents of N, P, K and Mg (mg/g dry weight): Results in Fig 1 revealed that, leaf area (cm^2) significantly increased by all treatments as compared with control. Potassium citrate at 1895 (T6) and 1263 (T 5) g/tree gave the highest values (110.0 and 155.0 cm^2) in the first and second season, respectively. Meanwhile, control treatment recorded the lowest leaf area science it was (76.5 and 96.5 cm^2) during both studied seasons.

As for leaf mineral content, data as mg/g dry weight showed that nitrogen content in leaves was significantly affected by treatments in both seasons of study. Potassium citrate (T 5) and mono potassium phosphate (T 8) recorded the highest values of leaf N content (2.33 and 2.32) and (2.35 and 2.29) in the first and second season, respectively. On the other hand, control treatment recorded the lowest values in this respect (1.62 and 1.63) during both studied seasons.

Regarding phosphorus, data presented in Fig. 1 showed that using mono potassium phosphate (T 8) gave the highest leaf phosphorous content at the first and second seasons (0.23 and 0.27), respectively. On the other contrary, control treatment recorded the lowest one (0.17 and 0.14) in both seasons.

Concerning potassium content in leaves, data presented in Fig. 1 indicated that, potassium citrate (T 6) gave the highest value of potassium content in leaves (1.91 and 1.92) during both studied seasons, respectively. On the other contrary, control treatment gave the lowest one (1.47 and 1.47) in this respect.

As for magnesium, it is obvious from Fig. 1 that magnesium content in leaves was significantly affected by treatments especially when trees received potassium citrate (T 5 and 6) in the first season (0.20 and 0.21), respectively. In the second season, the most of treatments significantly increased leaf magnesium content than the control treatment.

Number of Fruits and Yield (Kg/tree): Data presented in Fig. 1 revealed that, yield expressed as number of fruits and weight (Kg/tree) was significantly increased by all different treatments as compared with control. Untreated trees (control) had the lowest number of fruits (179.0 and 211.0) and yield (44.25 and 79.60) in the first and second seasons, respectively. On the other hand, trees received potassium citrate (T 6) reached the maximum number of fruits/tree (420.0 and 649.0) and yield as kg\tree (130.65 and 218.84), respectively, followed by potassium citrate (T5) during both studied seasons. In addition, the other treatments recorded intermediate values in this respect.

Fruit Physical Characteristics

Fruit Weight (g) and Volume (cm^3): Data in Fig. 1 clearly showed that all treatments significantly increased fruit weight and volume during both studied seasons. In the first season, the heaviest fruit were recorded due to using potassium carbonate (T 3) since it was (412.0). Meanwhile in the second season, feldspar (T 2 and 1) recorded the heaviest in this respect (438.33 and 418.67). On the other contrary, mono potassium phosphate (T 8) recorded the lowest fruit weight during both studied seasons (242.0 and 268.33 g).

Concerning fruit volume (cm^3), data in Fig. 1 revealed that potassium carbonate (T 3) recorded the highest fruit volume in the first season since it was (320.0 cm^3). Meanwhile the lowest one (196.67 cm^3) was obtained due to mono potassium phosphate (T 8). On the other contrary, in the second season there was no significant differences obtained between control and other treatments.

Fruit Length (cm), Width (cm) and Shape Index: It could be obviously noticed from Fig. 1 that, fruit length was significantly affected by different potassium forms application at both seasons under investigation. Potassium carbonate and citrate gave higher fruit length than other treatments for both seasons. As for, Potassium carbonate (T3 and 4) gave (12.67and 12.5) in the first season and (12.67 and 12.33) in the second season for

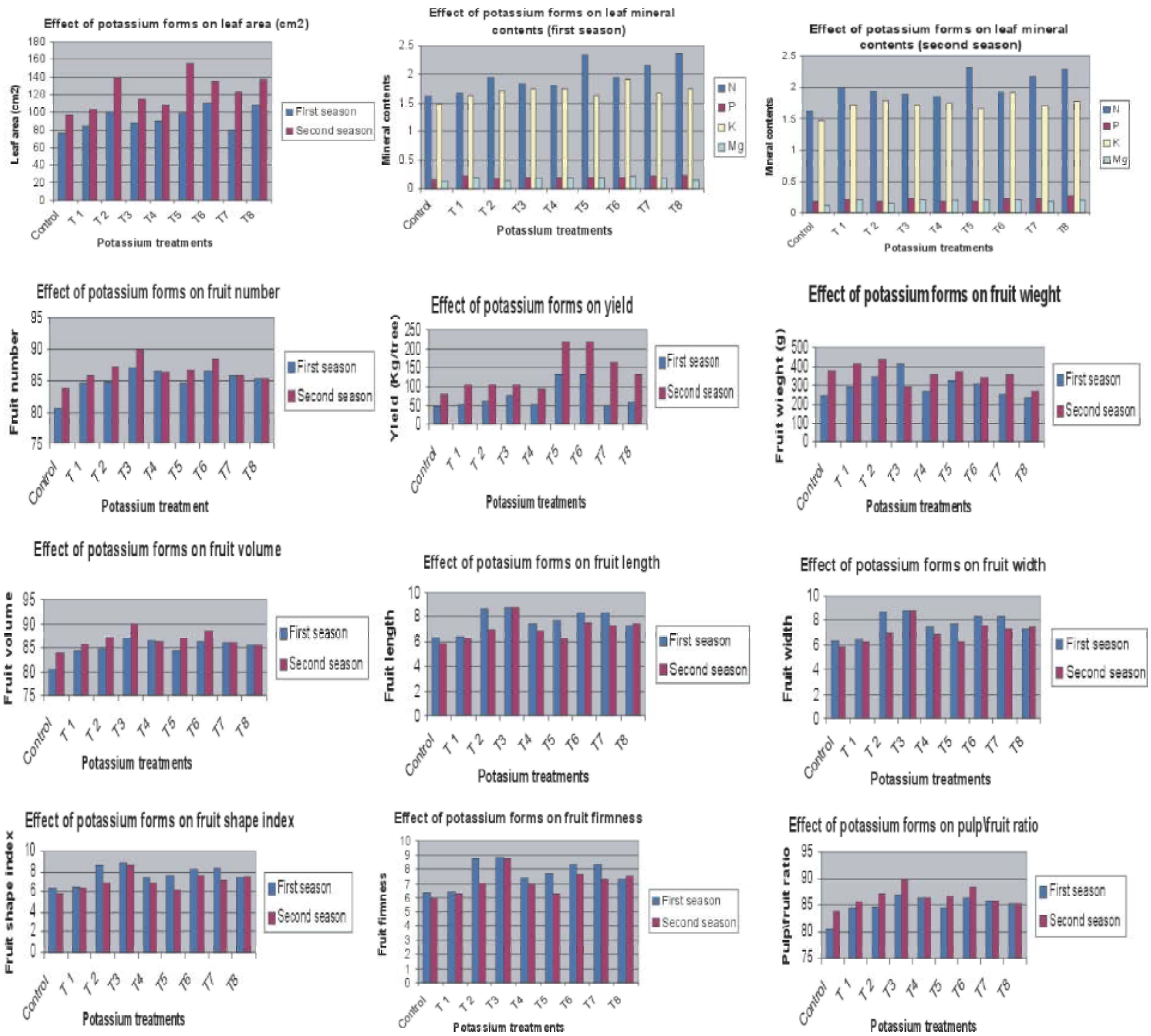

Fig. 1: Effect of various potassium forms on leaf area (cm^2), leaf mineral content (mg/g DW), fruit number/tree, yield (Kg/tree) and fruit physical properties: fruit weight (g), fruit volume (cm^3) fruit length and width (cm) fruit shape index (L/D), pulp\fruit ratio, fruit firmness ($Ib/inch^2$).

fruit length. In addition, Potassium citrate (T 6) recorded the highest fruit length (12.17 and 13.33) in the first and second seasons, respectively, with no significant differences between the two potassium forms. Meanwhile, control treatment gave the lowest one in this respect since it was (10.33 and 10.33 cm) during both seasons of study.

Regarding fruit width, as shown in Fig. 1 the obtained results indicated that untreated trees exhibited the lowest fruit width (7.17 and 7.30 cm) in two studied seasons, respectively. On the other contrary, trees received feldspar (T 2), Potassium carbonate (T3) and Potassium citrate (T 6) surpassed other treatments for fruit width in both seasons of study, with no significant differences between the three forms of potassium in both seasons.

As for fruit shape index, there were no significant differences in fruit shape index between different potassium forms in both seasons of study.

Fruit Firmness and Pulp/fruit Ratio: Data presented in Fig. 1 revealed that with respect to fruit firmness, there were no significant differences between the sources of potassium in the first seasons, from the statistical view. Meanwhile, in the second season, potassium carbonate

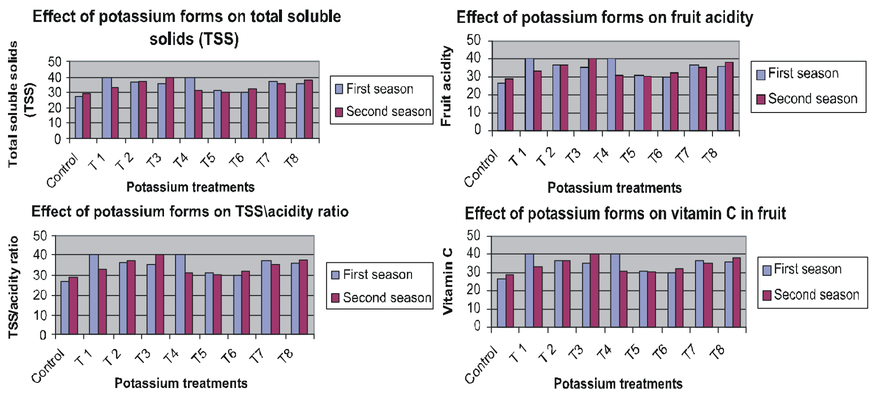

Fig. 2: Effect of various potassium forms on fruit chemical properties: TSS%, acidity, TSS% /acidity ratio, vitamin C (mg/100g F.W.).

(T 3) recorded the highest value of firmness (8.72) as compared with control treatment, which gave the lowest value (5.91).

As for pulp/fruit ratio, data presented in the same Figure indicated that, pulp/fruit ratio was significantly affected by different potassium forms in both seasons of study. The highest significant value was recorded with potassium carbonate at (T 3) since it was (86.74 and 89.9) in both studied seasons. On the other contrary, control treatment recorded the lowest value in this respect since it was (80.56 and 83.82) during both seasons of study.

Fruit Chemical Characteristics: The results shown in Fig. 2 illustrated the effect of different potassium forms on total soluble solids percentage (TSS%), acidity and vitamin C as mg/100g pulp. The obtained data revealed that TSS was significantly affected with different potassium sorts in the first season as compared with control since; control gave the lowest value (9.17) while potassium carbonate (T 3) recorded the highest value (13.0) in this respect. On the other contrary, there was no significant difference was detected between different treatments concerning TSS in the second season.

Concerning fruit acidity and TSS/acidity ratio, statistical analysis of data showed that there were no significant differences obtained between different potassium forms during both seasons of study.

Regarding vitamin C it is clear from data in Fig. 2 that vitamin C as mg/100 g pulp was significantly increased by all different treatments of potassium. Feldspar (T 1) and potassium carbonate (T 4) gave the highest value (40.0 for both) in the first season and potassium carbonate (T 3) gave the highest value in the second season. On the other side, control treatment gave the lowest value (26.67 and 29.0) in the first and second seasons, respectively.

DISCUSSIONS AND CONCLUSION

The present results, regarding the influence of different potassium forms on leaf area and its mineral content, are in accordance with those found by Ebeed and Abd El-migeed [2] as spraying Fagri Kalan mango with potassium citrate improved nitrogen and potassium in leaves. In addition, Abd El–Razek *et al*. [22] found that spraying mango trees with Sward (25% potassium) improved tree growth (as leaf area) and raised leaf mineral content of N, P and K.

Regarding yield, the obtained results are in harmony with these of Oosthuyes *et al*. [3] who found that productivity of several mango cultivars was improved by potassium sprays. Moreover, Abd El-Razek *et al*. [22] and Ebeed and Abd El-migeed [2] found that mango yield as number of fruits/tree or as weight (Kg/tree) were increased and reached to maximum by spraying with potassium. This due to beneficial effect on increasing fruit set, fruit retention and decreasing fruit drop and improving nutritional status of trees. In addition, the obtained results may confirm the previous work done by Oosthuyes [3], Abd El–Migeed *et al*. [23] and Saleh *et al*. [24]. They reported that yield of mango and orange were increased by potassium application.

Concerning fruit physical properties as (weight, volume, length, width, shape index, firmness and pulp/fruit ratio) the present results are in accordance with those of Stino *et al*. [25], Abd El-Razek *et al*. [22] and Ebeed and Abd El-Migeed [2] on mango trees. They reported that potassium improved fruit quality. In additions, the crucial importance of potassium in quality formation stems from its role in promoting synthesis of photosynthates and their transport to fruit. In addition, potassium influences on fruit quality can be also indirect as a result of its positive interaction with other nutrients especially with nitrogen and production practices [8].

With regard to the effect of different potassium application on fruit chemical properties the obtained results are in agreement with those of Stino *et al*. [25], Abd El-Razek *et al*. [22] and Ebeed and Abd El-Migeed [2] on mango trees. They found that potassium improved fruit chemical properties as TSS, acidity and vitamin C. In addition, Kumar *et al*. [26] found that potassium have profound influence on fruit chemical properties through its influence on soluble solids, acidity and vitamin C content.

CONCLUSION

From the abovementioned results, we can conclude that all soil application of different potassium forms had a positive effect on increased leaf area as well as mineral content and improved yield, fruit physical and chemical properties as compared with control of Zebda mango tree. Potassium citrate at 1263, 1895 and mono potassium phosphate at 2000 g per tree were the best treatments to increased leaf area and improvement leaf mineral content. In addition, potassium citrate at 1895 and potassium carbonate at 850 g per tree were the most effective treatments in enhancing yield and improved fruit quality as well as physical and chemical properties.

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