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RESPONSE OF PAIRI MANGO TREES TO POTASSIUM AND PHENYLALANINE FOLIAR APPLICATIONS:
I-YIELD, ENHANCING FRUIT COLOUR AND IMPROVING QUALITY

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ABSTRACT

The present investigation was conducted during 1997 and 1998 seasons to study the effect of potassium and phenylalanine foliar sprays on Pairi mango trees. The experimental results revealed that fruit yield, expressed as kg/tree or fruit number per tree, generally, increased as the levels of potassium increased. The best results in this respect were obtained by using 3% K_2O. In the meantime, results showed that phenylalanine did not affect the number of fruits per tree, but significantly increased the yield as kg per tree. In both years of study, peel total chlorophyll, generally, decreased, while carotene and anthocyanin increased by the foliar application of both K_2O and phenylalanine.

Both potassium and phenylalanine foliar applications did not influence mango fruit firmness.

Results also revealed that potassium and phenylalanine treatments caused an increase in reducing, non-reducing and total sugars on one hand, and reduction in starch on the other.

Spraying Pairi mango trees with both potassium and phenylalanine increased total soluble solids and vitamin C. As for fruit acidity, potassium caused an increase in fruit juice acidity, while phenylalanine seemed not to affect fruit juice acidity.

INTRODUCTION

The mango is the second largest tropical fruit in terms of production and acreage in Egypt, and it is one of the important fruit crops of the world, greatly relished for its exotic flavour, succulence and delicious taste. There are traditional Indian and many important commercial local cultivars grown in Egypt, which may be classified according to their different characteristics, such as tree growth, vigor, yield, fruit colour, harvest season, … etc. For convenience, they are easily separated by fruit colour into two classes: green and coloured cultivars; i.e., Pairi mango cultivar which is one of the three important Indian cultivars (Alphonse, Pairi and Totapuri), whereas, its fruit colour is yellow with red blush (Litz, 1996).

The external colour of the fruit is an important factor in consumer preference. The principal pigments in the fruit are chlorophylls, carotenes and anthocyanins (Medlicott *et al*., 1986).

Potassium is known to influence mango yield through its effect on fruit set, fruit weight and improving fruit quality by increasing sugar content and enhancing colour (Marschner, 1986).

Sedletskii *et al*.(1988) found that the application of the amino acid: phenylalanine to Rkatsiteli grapevines as foliar spray enormously encouraged and stimulated the development of red pigmentation. The key reaction in the biosynthesis of the red pigment, anthocyanin, is the oxidative deamination of phenylalanine to ciannamic acid, by the phenyl ammonialyase (PAL) enzyme system. The presence of this enzyme system in mango was quite acknowledged by Medlicott (1986).

Accordingly, the aim of this investigation was to evaluate the efficiency of both potassium and the nutritive amino acid; phenylalanine on yield and some fruit quality of Pairi mango cv.

MATERIALS AND METHODS

This study was carried out during two successive seasons of 1997 and 1998, on mango trees (*Mangifera indica* L.) cv. Pairi, about 16 years old grown in private orchard in the Alex.-Cairo highway, where the soil is sandy with pH 7.2 and 8.0% $CaCO_3$, using drip irrigation system. The trees were as uniform as possible, planted at 7x7 meters. All trees received ammonium sulphate and potassium sulphate at a rate of 900 g N and 440 g K_2O / tree / year. Phosphoric acid at a rate of 45 L was annually added per feddan in several additions each did not exceed 50 ppm in irrigation water. Irrigation was provided at 1 L/4 hr daily during each growing season through two trickle irrigation emitters per tree, located within 30 cm of the tree.

In both experimental seasons, the trees were sprayed three times at March, May and July with water (control), 1, 2 and 3% of potassium sulphate (K_2O) or 15, 30 and 45 ppm phenylalanine. Each tree received 7 liters of the spray solution.

Each plot included one tree and each treatment was replicated four times in a randomized block design.

In both seasons, the yield was recorded at the first week of August for each treatment as number of fruits per tree and yield weight was estimated by multiplying number of fruits x average weight of fruit.

Ten matured fruits (when the fruit shoulders are filled and at the beginning of colouration) of each treatment were taken to determine fruit characteristics. Fruit firmness was determined by Magness and Taylor (1925) pressure tester. In fruit juice, total soluble solids (TSS) were determined by using a hand refractometer. Acidity was estimated as malic acid and vitamin C content was determined using 2, 6-dichlorophenol indophenol dye (A.O.A.C., 1980). Peel chlorophyll and carotene (mg/100 g fresh weight) were colourimetrically determined according to the procedure outlined by Wensttein (1957). Anthocyanin was determined (mg/100 g fresh weight) according to Rabino *et al*.(1977).

The reducing sugars were determined by Nelson method as illustrated by Malik and Singh (1980). The total soluble sugars were determined after hydrolysis with hydrochloric acid and non-reducing sugars were calculated by the difference between the total soluble sugars and reducing sugars. The starch was determined in 0.1 g of the residue by hydrolysis using concentrated HCl for three hours under reflux condenser (A.O.A.C., 1980).

Pectic fractions were determined according to McComb and McCready (1952).

The data collected throughout the course of this study were statistically analyzed using the analysis of variance method (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Yield :

Data illustrated in Tables (1 and 2) evidently showed that fruit yield, expressed as kg/tree or fruit number per tree, generally, increased as the levels of potassium increased. The best productivity in this respect were obtained by using K_2O at 3% concentration. Results were nearly the same in both seasons. These results were similar to the findings of Salem (1984) and Abd El-Aal *et al*.(1994) working on mango. The beneficial effect of potassium in increasing fruit number per tree may be due to increasing fruit set as mentioned by Thakur *et al*.(1983).

In addition, data also showed that K treatments caused an increase in fruit weight. Significant differences were only found when trees were sprayed with K_2O at 2 and 3% as compared with control in both experimental seasons.

Potassium caused a direct increase in mango fruit yield by two ways. First, by increasing the number of fruit/tree as explained before. Second, by increasing the fruit weight which can be explained by the role of K in expanding cells of fruit, cell extension involves the formation of a large central vacuole that especially in the fruit can occupy 90% more of the cell volume (Marschner, 1986).

As for the effect of phenylalanine foliar spray on yield, results showed that phenylalanine did not affect the number of fruits per tree, but significantly increased the yield as kg per tree. Significant differences were found between the highest two concentrations (30 and 45 ppm) as compared with the control in both experimental seasons (Tables 1 and 2).

The increase in yield as kg/tree due to the phenylalanine applications could be explained by the effect of phenylalanine in increasing fruit weight compared with the control. Significant differences were found between the highest concentrations (30 and 45 ppm) as compared with the control in 1997 and 1998 seasons (Tables 1 and 2).

The increase in mango fruit weight might be attributed to the influence of phenylalanine in stimulating IAA synthesis. Bidwell (1979) reported that phenylalanine participates in the reactions leading to the formation of tryptophane, the precursor of IAA. The effect of IAA in increasing the growth of mango fruits gains acceptability.

Although phenylalanine applications did not affect the number of fruits/tree, they apparently increased fruit weight (Tables 1 and 2). The accumulation of sugar in mango fruits in response to phenylalanine, might help in interpretation of these results. It might be assumed that more water moved into the mango fruit cells to adjust the diffusion pressure deficit arising due to sugar accumulation (Marschner, 1986).

1+2

Total chlorophyll, carotene and anthocyanin :

Changes in colour in mango peel included destruction of chlorophyll, revelation of pigments previously masked and synthesis of new pigments; carotenes and anthocyanins (Medlicott *et al*., 1986). Data in Tables (1 and 2) showed that, in both years of study, peel total chlorophyll, generally, decreased by the foliar application of both K_2O and phenylalanine. Significant differences were only found between the highest potassium concentration (3%) and both higher phenylalanine treatments (30 and 45 ppm), compared with control (untreated fruit trees).

Data, also, showed that carotene, generally, increased by all potassium and phenylalanine treatments as compared with control. Differences were not big enough to be significant, except for the highest concentration of potassium (3%), as compared with control in both experimental seasons. The synthesis of carotenoids in mango involves mevalonic acid and geraniol as precursors (Mattoo *et al*., 1968); i.e., the isoprenoid pathway. These two compounds accumulate before the climacteric rise, but decrease in concentration during the climacteric period. Since a concomitant increase in phosphatase activity was also observed, Mattoo *et al*.(1968) concluded that phosphatase activity is an important regulatory factor in mango carotenogenesis. This last process seems to be accompanied both in the peel and the pulp by changes in the ultrastructure of plastids (Parikh and Modi, 1990).

It was evident from the data presented in Tables (1 and 2) that potassium treatments, generally, increased red colouration of the peel of Pairi mango fruit as compared with control in both 1997 and 1998 seasons. Differences were not big enough to be significant, except for the highest K_2O concentration (3%) in both seasons of study. These results agreed with Medlicott *et al*.(1986) working on mango fruit. In the meantime, phenylalanine greatly improved the red colouration of Pairi mango fruit peel. In both experimental seasons, all foliar applications of phenylalanine significantly increased the concentration of anthocyanin in comparison with control, except for the lowest concentration in the second season. These results agreed with those of Sedletskii *et al*.(1988) and Ezz (1994) working on grapes.

The biosynthesis of anthocyanin is believed to operate through the shikimic acid pathway (Malik and Srivastava, 1982). The initial step in this pathway is the deamination of phenylalanine to trans-cinamic acid by the induced enzyme system phenylalanine ammonia-lyase (PAL). The presence of PAL enzyme system in mango has been identified by Medlicott *et al*.(1986). Thus, the increase in anthocyanine content of mango fruit skin as a response of phenylalanine treatments is expected.

Fruit firmness :

Data of the present investigation showed, in both seasons of study, that both potassium and phenylalanine foliar applications did not influence mango fruit firmness (Tables 1 and 2).

Carbohydrate fractions :

The data of the present study (Tables 1 and 2) revealed that the different carbohydrate fractions seemed to have a relation with various foliar treatments of both potassium and phenylalanine foliar applications in Pairi mango fruits. In both experimental seasons, results showed that potassium treatments caused an increase in reducing, non-reducing and total sugars on one hand, and a decrease in starch on the other. Significant differences were found between the higher two potassium concentrations (2 and 3%) and control in the first season and the highest potassium concentration (3%) and control in the second season. These results were in line with those reported by Marschner (1986) and Malhi *et al*. (1988).

Data, also, showed that reducing, non-reducing and total sugars in Pairi mango fruits increased as a result of phenylalanine applications (Tables 1 and 2). In addition, starch percentage tended to decrease by phenylalanine applications. Significant differences were found as a result of the three phenylalanine applications in the first season and highest two concentrations (30 and 45 ppm) in the second season.

These behaviour patterns of the different sugar fractions might be in accordance with those reported by Sedletskii *et al*.(1988), who found that foliar application of phenylalanine increased the sugar content in grapes.

Total soluble solids (TSS) :

The data of the present investigation showed that the total soluble solids (TSS) of Pairi mango fruits seemed to be affected by either potassium or phenylalanine treatments (Tables 1 and 2).

During both experimental seasons, spraying mango trees with both potassium and phenylalanine caused significant increase in fruit TSS, except for the lowest concentration of K (1%) in the first season. These results seemed to be in line with those obtained by Khalil *et al*.(1987) on Egyptian blood orange and Abd El-Aal *et al*. (1994) on Hindi-Bi-Sinara mango. In addition, the increase of total soluble solids (TSS) in mango fruit juice due to the phenylalanine foliar treatments agreed with the findings of Sedletskii *et al*.(1988) and Ezz (1994) in grapes.

No doubt, the increase of the reducing sugars concentration, resulting from both potassium and phenylalanine applications would account for the total soluble solids increment observed herein.

Acidity :

The data in Tables (1 and 2) indicated that fruit juice acidity, generally, increased with potassium treatments. Significant differences were found in all treatments, except the treatment of K_2O at 1% as compared with untreated fruit trees (control). These results seemed to be in line with those obtained by Malhi *et al*.(1988) working on Deshehari mango. Also, these results could be explained according to the results of Marschner (1986), who reported that potassium plays a big role in the accumulation of organic acids in fruits.

During both experimental seasons, spraying Pairi mango trees with the three foliar applications of phenylalanine seemed not to affect fruit juice acidity (Tables 1 and 2). Similar findings were also reported by Sedletskii *et al*.(1988) and Ezz (1994) in grapes.

Vitamin C :

The data concerning the effect of the various foliar treatments of both potassium and phenylalanine on the ascorbic acid content of Pairi mango fruits are presented in Tables (1 and 2). It seemed quite clear that, during both experimental seasons, all treatments affected vitamin C content, comparable to its value in the control fruits. Significant differences were found within all treatments and control, except for the lowest potassium concentration (1%). In accordance with these results are those reported by Malhi *et al*.(1988) in Dashehari cv. of mango.

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إستجابة أشجار المانجو صنف بيرى للرش بالبوتاسيوم والفينيل ألانين
1- المحصول وتلون الثمار وجودتها

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أجرى هذا البحث خلال موسمى 1997 ، 1998 لدراسة تأثير الرش الورقى بالبوتاسيوم والفينيل ألانين على أشجار المانجو صنف بيرى. وقد أوضحت النتائج زيادة المحصول من الثمار لكل شجره سواء على أساس عدد الثمار أو وزن الثمار مع زيادة معدلات البوتاسيوم. وكان أعلى تأثير نتيجة لاستعمال 3% بوأ$_2$.

وفى نفس الوقت فإن النتائج بينت أن الفينيل ألانين لم يكن له تأثير على عدد الثمار للشجره بينما زود معنوياً من المحصول بالكيلوجرام للشجره.

كما بينت النتائج خلال موسمى الدراسة نقص محتوى القشرة من الكلوروفيل الكلى وزيادة محتواها من الكاروتين والأنثوسيانين نتيجة للمعاملة بكل من بوأ$_2$ والفينيل ألانين. ولم يؤثر الرش بكل من البوتاسيوم والفينيل ألانين على صلابة ثمار المانجو.

كذلك بينت النتائج أن معاملات البوتاسيوم والفينيل ألانين سببت زيادة فى محتوى الثمار من السكريات المختزلة وغير المختزلة والكلية ونقص فى محتواها من النشا.

وقد أوضحت النتائج أن رش أشجار مانجو بيرى بكل من البوتاسيوم والفينيل ألانين زود من محتوى الثمار من المواد الصلبة الذائبة وفيتامين جـ. كما أدت المعاملة بالبوتاسيوم الى زيادة حموضة الثمار بينما لم تؤثر معاملة الفينيل ألانين على حموضة الثمار.

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Table (1):Effect of potassium and phenylalanine foliar applications on yield and fruit quality of Pairi mango in 1997 season.

Treatments	Yield (kg/tree)	No of fruits per tree	Fruit weight (g)	Total chlorophyll (mg/100 g)	Carotene (mg/100 g)	Anthocyanin (mg/100 g)	Firmness (pounds/inch²)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Starch (%)	TSS (%)	Acidity (%)	Vitamin C (mg/100 ml)
Control	69.5	313.8	221.5	19.46	1.23	3.15	12.11	0.261	5.79	6.05	2.47	7.22	1.82	41.5
K_2O, 1%	71.0	316.4	224.3	18.11	1.39	3.81	12.16	0.264	5.93	6.19	2.46	7.94	1.84	42.7
K_2O, 2%	72.7	320.9	226.5	16.91	1.43	4.11	12.17	0.371	6.15	6.52	2.31	8.11	1.95	48.7
K_2O, 3%	74.7	325.1	229.9	16.03	1.47	4.67	12.21	0.515	6.28	6.80	2.11	8.17	1.97	49.9
φ alanine, 15 ppm	72.2	319.4	226.1	17.93	1.31	4.84	12.14	0.206	6.04	6.34	2.23	8.02	1.80	42.6
φ alanine, 30 ppm	76.5	318.9	239.9	15.49	1.35	5.14	12.16	0.497	6.41	6.91	2.14	8.18	1.79	44.1
φ alanine, 45 ppm	77.9	319.7	243.7	15.31	1.37	5.33	12.17	0.581	6.64	7.22	2.01	8.22	1.82	44.7
$L.S.D_{0.05}$	5.0	10.9	4.8	3.35	0.21	1.40	N.S	0.11	0.22	0.27	0.41	0.85	0.12	7.1

Table (2): Effect of potassium and phenylalanine foliar applications on yield and fruit quality of Pairi mango in 1998 season.

Treatments	Yield (kg/tree)	No of fruits per tree	Fruit weight (g)	Total chloro-phyll (mg/100 g)	Carotene (mg/100 g)	Anthoc-yanin (mg/100 g)	Firmness (pounds /inch²)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Starch (%)	TSS (%)	Acidity (%)	Vitamin C (mg/100 ml)
Control	69.87	324.7	217.2	18.27	1.39	3.22	11.33	0.249	5.51	5.76	2.53	7.27	1.80	43.7
K_2O, 1%	72.36	329.9	223.4	18.01	1.41	3.93	11.37	0.251	5.83	6.08	2.50	7.89	1.87	44.6
K_2O, 2%	75.91	333.1	227.9	16.31	1.43	4.07	11.39	0.299	6.07	6.37	2.42	8.07	1.90	47.3
K_2O, 3%	77.37	337.7	229.1	16.05	1.52	4.84	11.41	0.496	6.19	6.69	2.21	8.19	1.92	49.6
φ alanine, 15 ppm	73.54	325.1	226.2	17.11	1.41	4.17	11.35	0.269	6.03	6.30	2.33	8.00	1.79	43.9
φ alanine, 30 ppm	76.96	327.9	234.7	15.44	1.43	4.86	11.37	0.347	6.27	6.62	2.08	8.12	1.81	43.9
φ alanine, 45 ppm	78.26	327.3	239.1	15.19	1.46	5.21	11.42	0.587	6.39	6.98	2.05	8.21	1.81	43.8
$L.S.D_{0.05}$	6.33	12.3	9.30	2.15	0.12	1.51	NS	0.220	0.60	0.83	0.31	0.60	0.05	3.4