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Improving of Fruit Set, Yield and Fruit Quality of "Khalas" Tissue Culture Derived Date Palm Through Bunches Spraying with Potassium and/or Boron

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Abstract: The objective of the present paper is for studying the impact of bunches spraying with K and/or B on fruit set, fruit yield and fruit quality characteristics. The present study was carried out during 2008/2009 growing seasons on date palm, "Khalas" cultivar. Bunches were spraying at three times; 2 hrs before pollination, 4 and 8 weeks after pollination. Eight spraying treatments were performed; spraying with potassium citrate solution at rates of 1, 2, and 3%, spraying with boric acid solution at rates of 0.1, 0.2 and 0.3% , spraying with mixed solution of potassium citrate at 2%+boric acid solution at rate of 0.2% besides the control treatment(spraying with distilled water). The present results indicated that spraying date palm bunches with K and/or B, significantly increased the fruit set. The superior treatment was 2%K-citrate+0.2% boric acid solution, the increment is account as 53.64 and 56.66% over control for both seasons. The same effect was noticed with fruit yield, the highest yield was obtained with K+B solution by 44.67 and 44.19% over control for both seasons. Fruit physical and chemical characteristics were significantly improved with spraying bunches with K or/and B solution except for seed weight and acidity. Potassium and/or boron spraying treatments markedly increased fruit contents of macro and micro-nutrients. The highest nutrients content was noticed with K+B (2%K-Citrat+0.2%Boric acid) solution treatment. In general the results showed that K or B or mixed have a significant effect in increasing the fruit set, fruit yield and improving the fruit quality. Also, the data showed that superiority of K+B spraying treatment (2%K-Citrat+0.2%Boric acid).

Key words: Date palm; fruit set; fruit quality; boron spraying; fruit yield; potassium spraying

INTRODUCTION

The date palm (*Phoenix dactylifera* L.) has been an important crop in arid and semi-arid regions of the world. Date palm is one of the ancient domestic fruit trees in the Middle East countries and their fruits play an important role in the nutrition pattern of many people. It has always played an important role in the economic and social life of the people of these regions. Date palm is a major fruit tree in Saudi Arabia. The total production of date fruits was about 986409 tons from (157074 ha) 23458299 trees (Agricultural Statistical Year Book, 2009). In Saudi Arabia, more than 400 cultivars are grown in different regions according to the variability of their climatic conditions, but "Khalas" is the most important cultivar in Saudi Arabia. In each region, soil conditions are different, which possibly lead to lower nutrient uptake in inflorescences and fruits and consequently the reproductive potential don't become observable. One of the best tools for date palm reproductive potential studies is the direct application of nutrient elements on inflorescences and fruits (Al-Khateeb *et al*., 2006, Zaid and Arias-Jimenez, 2002).

The development of tissue culture propagation methods has enabled date palm to be rapidly propagated on a large scale. The production of genetically uniform and stable in vitro date palms has a critical importance. Unfortunately, undesirable plant off-types produced by somaclonal variation are quite common among date palms (Cohen *et al*., 2004; Gurevich *et al.*, 2005). Low levels of fruit set and supernumerary carpels were detected in many date palm trees produced by tissue culture. In Saudi Arabia, more than 100,000 tissue culture- derived date palm trees were severely affected (Djerbi, 2000). All pollinated bunches showed 80-100% parthenocarpic fruits with the development of more than 3 carpels. Varughese (2000) reported abnormalities in fruiting ability and fruit characteristics, e.g. abnormal fruit size and shape, in tissue culture-derived date

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palms. In this respect, Bouhouche *et al*. (2007) reported that low levels of fruit set and the formation of multicarpel parthenocarpic fruits in many date palm trees are produced by tissue culture.

Impact of some macro and micro elements on date palm yields and fruit quality were reported by many investigators (Al-Hamoudi, 2006; Moghimi, 2007; Etman *et al*., 2007; Attalla *et al*., 2007; Westover and Kamas, 2009). A serious problem facing the date palm growers through the different regions is fruit set. Many investigators mentioned the effect of micro-elements in pollen grains germination and pollen tube growth in many plant species. These nutrients, such as boron seem to play an important role in achieving a satisfactory fruit set (Talaie *et al*, 2001; Wojcik and Wojcik, 2003; Baldi *et al*., 2004; Khayyat *et al*., 2007). Also, macro-elements such as potassium showed a great role in controlling cell water content and carbohydrates biosynthesis and mobilization in plant tissues, consequently carbohydrates play a serious role in fruit set (Abdel- Bary, 1999; Saleh and El-Monem, 2003; Shahin, 2007; Harhash and Abdel-Nasser, 2007; Khayyat *et al*, 2007).

Potassium is an important solute in expanding cells, and expansive growth is very sensitive to K deficiency. Also potassium is needed for the enlargement of fruit (Marschner, 1995). potassium activates the enzymes involving in sugar biosynthesis and helps in translocation of sugars (Archer, 1988)

Many investigators studied the effect of potassium and/or boron spraying on fruit set, yield and fruit quality of fruit crops. Al-Hamoudi (2006) studied the spraying of Barhee date palm with 0.4% potassium sulfate or boric acid at 40 ppm, He found a significant increasing in fruit set, physical and chemical fruit quality parameters. The same trends were noticed by Saleh and El-Monem (2003) on mango; Attia *et al*.(2001) with banana; Coban (2002) with grape; Hassanein (2004) with peach.

The objective of the present study is to improve the fruit set of "Khalas" date palm trees derived from tissue culture through spraying bunches with B and/or K solution and to clarify the impact of spraying on yield, fruit quality and nutrients content.

MATERIALS AND METHODS

The present study was conducted through two growing seasons 2008 and 2009 on 10 years old "Khalas" date palm trees grown in private orchards at Hail (42° 25′ 23.5" E, 27° 10′ 25.4" N and 790 m above see level), Saudi Arabia. Table (1) shows some soil physical and chemical characteristics of the experimental site according to the methods outlined in Klute (1986) and Carter (1993). Twenty four uniform trees in size and vigor as far as possible were selected. The palm trees were produced throughout the tissue culture technique, therefore the trees have low levels of fruit set and yield according to the historical records. The trees were treated according to the usual farm management, for example, artificial pollination, pruning, irrigation, fertilization and manuring. The palms were pruned at a level maintaining all palms possessing the same number of function leaves (72 leaves/palm). The number of bunches per palm was adjusted to 8 of nearly equal size by removing the excess ones from the latest and earliest small ones. The leaf/bunch ratio was adjusted by the end of blooming to be 9:1 in both seasons. Pollination was achieved by using pollen grains from the same parents in both seasons. As there were originally 80 to 120 strands on each bunch of Khalas palms, the number of strands was reduced to 75, so each bunch contained the same number of strands. The ordinary fertilization program was done, 20 kg of cheep manure (3.21, 0.73 and 1.11 % of N, P and K, respectively) per tree were added during winter, 1000 g of triple calcium super phosphate (45% P_2O_5) per tree were broadcast on the soil surface through the whole area during December and 1200 g N per tree as ammonium nitrate (31% N) were broadcast on the soil surface through the whole area during March, May and July.

Bunches were spraying at three times; 2 hrs before pollination, 4 and 8 weeks after pollination. All treatments were applied separately. Sprays were applied by small spraying motor until run-off stage. Wetting agent Tween 20 (1%) was applied with spraying solution. The eight spraying treatments were: Control (distilled water), Potassium citrate, 1%, Potassium citrate, 2%, Potassium citrate, 3%, Boric acid, 0.1%, Boric acid, 0.2%, Boric acid, 0.3%, and Potassium citrate(2%)+ Boric acid (0.2%).

Measurements:

Fruit Set and Fruit Yield:

The number of nods and set fruits in twenty five strands per tree were recorded after 4 weeks of pollination. The percentage of fruit set was calculated using the following formula:

$$\text{Fruit Set}(\%)=\frac{\text{Total number of set fruit per strand}}{\text{Total number of nods per strand}}\times 100$$

At the harvesting time (Tamar stage), the fruit yield per palm was recorded (kg fruit per palm).

Table 1: Some physical and chemical characteristics of the experimental soil used in the present study

Parameters	Soil depth		
	0 – 30 cm	30 – 60 cm	60 – 90 cm
Particle-size distribution,%			
Sand	76.7	78.2	80.1
Silt	12.1	10.2	6.5
Clay	11.2	11.6	13.4
Textural class	Sandy loam	Sandy loam	Sandy loam
Organic matter content,%	0.89	0.63	0.75
Calcium carbonate content, %	7.95	8.65	7.42
pH	7.37	7.43	7.50
ECe, dS m^{-1}	1.75	1.87	2.11
Soluble cations, meq L^{-1}			
Na^{+}	3.33	3.76	4.69
K^{+}	0.33	0.25	0.32
Ca^{2+}	8.65	0.35	11.51
Mg^{2+}	4.95	5.31	6.45
Soluble anions, meq L^{-1}			
$CO_3^{=}$	-	-	-
HCO_3^{-}	3.04	2.91	3.05
Cl^{-}	5.95	6.80	9.00
$SO_4^{=}$	8.55	9.00	10.82

Fruit Quality:

Samples of 50 fruits were randomly collected at ripening stage, Tamar stage (late of October, 2008 and 2009) from each palm for determining the fruit physical characteristics; fruit weight was recorded, and length and diameter of the fruit were measured using a micrometer caliper. The volume of the fruit was determined by the water displacement method. After pitting, the weight of the seed was determined, and fruit flesh weight recorded. Chemical characteristics such as total soluble solids (TSS), total acidity, total soluble sugars, reducing sugars, non-reducing sugars and fruit moisture content, which were determined according to the methods of AOAC (2000).

Nutrients Content:

Leaf samples were collected in March 2008 and 2009 seasons. On each palm, five mature leaves (fronds) were chosen (one year old). Five pinnae were taken from the middle part of each leaf above fruiting zone as recommended by Embleton and Cook (1947). Each sample was collected randomly at a constant height and at all directions of the trees. At harvesting time, samples of 30 fruits were randomly collected at ripenning stage (late of October, 2008 and 2009) from each palm for determining the fruit elemental contents according to the recommended methods. Leaf and fruit samples were washed with tap water, distilled water, air-dried and oven dried at 65°C for 72 hrs. The dried samples were ground and then digested with concentrated Sulphuric acid+30% hydrogen peroxide according to the method of Wolf (1982). Total N was determined by micro-Kjeldahl method (Jackson, 1973). Phosphorus was determined according to the method of Murphy and Riely (1962). Potassium was determined by Flame Photometry (Jackson, 1973). Calcium, Magnesium and micronutrients (Fe, Mn, Cu and Zn) were determined by Inductively Coupled Plasma–Atomic Emission Spectrometry (ICP-AES). Boron was colorimetrically determined according to Jackson (1973).

Statistical Analysis:

The experiment was arranged in Randomized Complete Block Design (RCBD) with 8 treatments and 3 replications. All data were subjected to analysis of variance (ANOVA) using SAS software (SAS Institute Inc., 2001). Mean separation was carried out ($P<0.05$) using Tukey's significant difference test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Fruit set and Fruit yield:

Regarding the percentages of fruit set in response to K and/or B spraying treatments; it is evident from the data presented in Table (2) that all the studied treatments resulted in a significant increase in fruit set percentages compared with control in both experimental seasons. The percentages of increment of fruit set for K at 1, 2 and 3% K-citrate solution as compared with the control were 12.55, 23.28 and 30.97%, respectively in the first season; the corresponding values for the second season were 11.84, 23.04 and 31.71%. With respect to B, the percent increment of fruit set for B at 0.1, 0.2 and 0.3% boric acid solution compared with control

(zero K and B) were 24.49, 37.25 and 46.15%, respectively in the first season, and were 28.54, 44.40 and 51.16%, respectively, in the second season. The highest values of fruit set were obtained by spraying treatment of 2% K-citrate+0.2%boric acid. The increment is account as 53.64 and 56.66% for both seasons, respectively.

Fruit yield of "Khalas" date palm as affected by potassium or/and boron spraying are illustrated in Table (2). The data indicated that spraying date bunches with K and/or B increased fruit yield in both growing seasons. Increasing K or B rates increased fruit yield over the control treatment. Such increments compared with control were 8.83, 16.76 and 19.46% for K at 1, 2 and 3%, respectively, in the first season. Meanwhile, in the second season, they were 11.81, 21.71 and 25.33%, respectively. The corresponding values of increments for B at 0.1, 0.2 and 0.3% compared to control were 12.61, 21.80 and 26.31% in the first season and 15.62, 26.86 and 35.05% in the second season, respectively. But spraying bunches with both K and B has highest fruit yield. Therefore, the spraying solution of 2% K-citrate + 0.2% boric acid solution were the best treatment in our experiment. The increases were account as 46.67% and 44.19% over the control treatment for both seasons, respectively.

Foliar sprays of boron at the pre-bloom or bloom stages of fruit crops supplies available B at the critical periods of pollen formation, germination and fertilization just prior to seed and fruit set. Foliar applied boron is rapidly absorbed by the flowers. This application will help ensure that flowers have enough B to carry them through flowering, and fruit set. Also, boron increases flower production and retention, pollen tube elongation and germination, and fruit development (Callan *et al*., 1978).

Increasing fruit yield due to K and/or B spraying may be attributed to their effects in increasing fruit set. Also, it may be attributed to the role of B in enhancing many metabolic processes such as carbohydrate transport (Marschner, 1995; Mengel and Kirkby, 2001). The present results are in agreement with results of Al-Hamoudi (2006) on Barhee date palm, Etman *et al*. (2007), Attalla *et al.* (2007), Desouky *et al*. (2007), Shahin (2007), Behrooznam and Shirzadi (2007); Khayyat *et al.* (2007). They reported that K and B fertilization increased yield of date palm and improved the fruit quality.

The present results revealed that boron has more effect than K in increasing fruit set and fruit yield of date palm and both of K and B have a synergetic effect (Ahmed *et al*., 2009). Both of B and K are considered to be essential for actively growing region of plants such as bud development. According to Rerkasem (1996), boron is especially required more in meristematic cells than the mature tissues. Boron and potassium have been considered to be functional in the transport of carbohydrates and translocation of sugar (Katyal and Randhawa, 1983).

Table 2: Impact of K and/or B spraying on fruit set and fruit yield of "Khalas" date palm during 2008 and 2009 growing seasons.

Treatments	2008 growing season		2009 growing season	
	Fruit set (%)	Fruit yield (kg/palm)	Fruit set (%)	Fruit yield (kg/palm)
Control	49.4	55.5	47.3	52.5
1%K-Citrate	55.6	60.4	52.9	58.7
2%K-Citrate	62.9	63.8	65.2	64.9
3%K-Citrate	63.7	65.3	64.8	63.8
0.1%Boric acid	61.5	62.5	60.8	62.7
0.2%Boric acid	71.8	68.6	72.3	70.5
0.3%Boric acid	72.2	70.1	71.5	69.4
2%K-Citrate +0.2%Boric acid	75.9	81.4	74.1	75.7
$L.S.D_{0.05}$	1.65	1.72	1.48	1.38

Fruit Physical Characteristics:

The effect of K and/or B spraying treatments on fruit physical characteristics of Khalas date palm are presented in Table (3). Potassium and boron spraying significantly increased fruit physical characteristics i.e. fruit weight, volume, length, diameter and flesh (%) compared with the control treatment in both growing seasons. But seed weight did not affect. Increasing K or B spraying rate increased the values of these characters. Spraying bunches with both K and B solution was superior in increasing the physical characters in both seasons. This treatment increased the physical characters by about 11.46, 10.82, 13.08 and 20.38% over control treatment for fruit weight, volume, length, diameter, flesh (%) respectively in the first season. The corresponding increments in the second season were 10.88, 11.56, 14.16 and 25.46%, respectively.

Boron and potassium increase the rate of sugar transport to actively growing regions and also in developing fruits. Therefore, increasing fruit physical characters may be attributed to the improvement of fruit growth and uptake of K and B nutrients that accelerate metabolic processes. Similar findings were reported by Harhash and Abdel-Nasser (2007); Shahin (2007); Desouky *et al*. (2007); Khayyat *et al*. (2007).

Table 3: Impact of K and/or B spraying on fruit physical characteristics of "Khalas" date palm during 2008 and 2009 growing seasons

Treatments	Fruit weight (g)	Fruit volume (cm^3)	Fruit length (cm)	Fruit diameter (cm)	Seed weight (g)	flesh (%)
			2008 growing season			
Control (distilled water)	8.75	8.23	3.37	2.25	1.11	87.31
1%K-Citrate	9.16	8.78	3.21	2.11	1.13	87.66
2%K-Citrate	9.51	9.25	3.59	2.53	1.14	88.01
3%K-Citrate	9.69	9.35	3.48	2.44	1.13	88.34
0.1%Boric acid	9.36	9.24	3.31	2.19	1.12	88.03
0.2%Boric acid	9.75	9.41	3.45	2.43	1.14	88.31
0.3%Boric acid	10.05	9.65	3.52	2.48	1.13	88.76
2%K-Citrate +0.2% Boric acid	10.46	9.93	3.63	2.54	1.12	89.29
$L.S.D_{0.05}$	0.40	0.27	0.11	0.09	ns	0.36
			2009 growing season			
Control (distilled water)	9.70	8.86	3.48	2.37	1.21	87.53
1%K-Citrate	10.11	9.69	3.32	2.16	1.20	88.13
2%K-Citrate	10.71	9.83	3.65	2.58	1.21	88.70
3%K-Citrate	10.97	9.41	3.70	2.51	1.20	89.06
0.1%Boric acid	10.75	9.58	3.39	2.27	1.17	89.12
0.2%Boric acid	10.94	9.61	3.62	2.59	1.19	89.12
0.3%Boric acid	11.09	10.45	3.68	2.53	1.17	89.45
2%K-Citrate +0.2% Boric acid	11.42	10.81	3.79	2.71	1.15	89.93
$L.S.D_{0.05}$	0.26	0.24	0.23	0.16	ns	0.42

Fruit Chemical Characteristics:

The effect of K and/or B spraying treatments on fruit chemical characteristics of Khalas date palm are presented in Table (4). Potassium and boron spraying significantly increased fruit chemical characteristics i.e. TSS, reducing, non-reducing and total sugars compared with the control treatment in both growing seasons, but moisture content of fruits was significantly decreased. Acidity was non-significantly affected in both season. Increasing K or B spraying rate increased the values of these characters. Spraying bunches with both K and B solution was superior in increasing the chemical characters in both seasons. The increments in chemical characters were 17.67, 14.98, 25.60 and 18.24% over control treatment for TSS, reducing, non-reducing and total sugars, respectively in the first season. The corresponding increments for the second season were 22.69, 20.03, 50.03, 32.03 and 23.64%, respectively. Fruit moisture content significantly, decreased by about 22.70 and 23.07% for both seasons respectively. Similar findings were reported by Harhash and Abdel-Nasser (2007); Shahin (2007); Desouky *et al*. (2007); Khayyat *et al*. (2007).

Potassium and boron has been considered to be functional in the transport of carbohydrates and translocation of sugar. This process may be enhanced by the formation of borate-sugar complexes (Gauch and Dugger, 1954; Price *et al*., 1972; Marcus-Wyner and Rains, 1982; Katyal and Randhawa, 1983).

Table 4: Impact of K and/or B spraying on fruit chemical characteristics of "Khalas" date palm during 2008 and 2009 growing seasons

Treatments	Moisture content (%)	Acidity (%)	T.S.S (%)	Reducing sugars (%)	Non-Reducing sugars (%)	Total sugars (%)
			2008 growing season			
Control (distilled water)	21.45	0.27	53.32	33.17	14.69	47.86
1%K-Citrate	17.22	0.28	57.42	35.34	15.87	51.21
2%K-Citrate	18.12	0.27	60.38	37.55	17.32	54.87
3%K-Citrate	19.34	0.29	61.67	38.12	17.85	55.97
0.1%Boric acid	17.44	0.30	54.69	34.64	16.26	50.80
0.2%Boric acid	18.87	0.28	59.45	36.78	17.11	53.89
0.3%Boric acid	19.38	0.30	60.14	36.89	16.75	53.74
2%K-Citrate +0.2%Boric acid	16.58	0.31	62.74	38.14	18.45	56.59
$L.S.D_{0.05}$	0.80	ns	1.33	0.98	0.66	1.56
			2009 growing season			
Control (distilled water)	23.15	0.25	51.46	31.45	13.52	44.97
1%K-Citrate	18.41	0.24	58.12	34.19	14.36	48.55
2%K-Citrate	20.10	0.26	61.19	37.01	17.32	54.33
3%K-Citrate	19.98	0.25	60.67	36.68	16.85	53.53
0.1%Boric acid	19.12	0.27	57.65	35.12	15.75	50.97
0.2%Boric acid	18.82	0.25	59.15	36.24	16.33	52.57
0.3%Boric acid	19.67	0.24	61.59	36.19	15.34	51.53
2%K-Citrate +0.2%Boric acid	17.81	0.25	63.14	37.75	17.85	55.60
$L.S.D_{0.05}$	0.53	ns	0.68	0.74	0.42	1.07

Fruit Nutrients Content:

The data in Table (5) show the impact of K and/or B spraying treatments on fruit nutrient contents of Khalas date palm in both seasons. It seemed that K spraying treatments markedly increased fruit contents of macro and micro-nutrients. The same trend was noticed with B spraying treatments. But spraying bunches with both K and B solution was more effective in increasing fruit nutrient contents. Potassium is essential for fruit enlargement and improves fruit growth. Moreover, potassium in some plants cause cell turgidity then improves uptake of nutrients and carbohydrates (Marschner, 1995; Mengel and Kirkby, 2001). Increasing fruit nutrients content is reflected in increasing the nutritional values of date palm fruits. It is interested here to notice that increasing fruit B and K contents is very important from the point of view of fruit nutritional value.

Table 5: Impact of K and/or B spraying on fruit nutrient contents of "Khalas" date palm in 2008 and 2009 growing seasons

Treatments	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B
	%					mg/kg				
2008 growing season										
Control (distilled water)	0.32	0.26	1.14	0.13	0.09	59.8	16.5	12.6	10.1	19.0
1%K-Citrate	0.34	0.27	1.18	0.15	0.11	60.4	16.9	12.9	10.7	19.7
2%K-Citrate	0.35	0.28	1.21	0.16	0.13	61.6	17.8	13.2	11.1	20.3
3%K-Citrate	0.36	0.30	1.22	0.18	0.14	62.4	18.3	13.6	11.3	20.5
0.1%Boric acid	0.35	0.28	1.17	0.17	0.11	60.9	17.1	13.2	10.7	20.0
0.2%Boric acid	0.36	0.30	1.21	0.19	0.13	61.8	17.4	13.5	11.3	20.6
0.3%Boric acid	0.38	0.32	1.23	0.20	0.14	62.6	17.7	13.9	11.6	20.6
2%K-Citrate +0.2%Boric acid	0.41	0.35	1.25	0.22	0.17	63.4	18.1	14.1	12.1	20.4
$L.S.D_{0.05}$	0.032	0.037	0.044	0.034	0.023	2.568	0.841	0.584	0.486	0.852
2009 growing season										
Control (distilled water)	0.33	0.27	1.13	0.14	0.09	60.3	16.2	13.2	11.3	20.0
1%K-Citrate	0.35	0.28	1.15	0.15	0.12	60.9	16.4	13.4	11.5	20.5
2%K-Citrate	0.37	0.29	1.17	0.17	0.13	61.7	16.7	13.6	11.7	20.6
3%K-Citrate	0.38	0.31	1.19	0.18	0.15	62.4	16.8	13.7	11.8	20.9
0.1%Boric acid	0.36	0.29	1.16	0.16	0.13	61.4	16.5	13.6	11.6	20.8
0.2%Boric acid	0.39	0.32	1.19	0.18	0.14	61.9	16.8	13.9	11.8	21.0
0.3%Boric acid	0.42	0.33	1.22	0.19	0.16	62.6	17.3	14.0	11.9	21.2
2%K-Citrate +0.2%Boric acid	0.43	0.35	1.25	0.21	0.18	63.1	17.5	14.1	12.0	21.0
$L.S.D_{0.05}$	0.035	0.029	0.041	0.031	0.025	1.583	0.734	0.749	0.547	0.624

Leaf Nutrients Content:

The data in Table (6) show the impact of K and/or B spraying treatments on leaf nutrient contents of Khalas date palm in both seasons. It seemed that K and/or B spraying treatments slightly increased leaf contents of macro and micro-nutrients, but this effect was non-significant. It is true because spraying date palm bunches has not effect the nutrient balance of leaves. The effect of spraying is has local effect on nutrient balance of date palm bunches only. Then the effect may be expected on fruit nutrient balance.

Generally, the most important outcome of the present study is to clarify the important role of K and/or B for improving the date palm pollen formation and flowering condition that enhance the fruit set and fruit yield of date palm. It is reflected on improving the fruit quality and increasing the nutritional value of date palm fruits. Therefore, according the present results spraying date palm bunches with solution of 2% potassium citrate + 0.2% boric acid pre- and after bloom will be useful for enhancing the pollen germination, pollen tube growth and fertilization that can improve fruit set and fruit yield of date palm (Khalas cv.).

Table 6: Impact of K and/or B spraying on leaf nutrient contents of "Khalas" date palm in 2008 and 2009 growing seasons

Treatments	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B
	%					mg/kg				
2008 growing season										
Control	1.15	0.11	0.62	0.82	0.31	278.5	39.4	4.7	16.5	44.8
1%K-Citrate	1.17	0.12	0.63	0.82	0.31	280.0	39.8	4.7	16.7	44.7
2%K-Citrate	1.18	0.12	0.63	0.83	0.31	281.0	40.0	4.8	16.7	44.7
3%K-Citrate	1.18	0.12	0.64	0.83	0.32	281.2	40.1	4.8	16.8	44.8
0.1%Boric acid	1.16	0.12	0.63	0.83	0.31	279.0	40.0	4.7	16.6	45.0
0.2%Boric acid	1.17	0.12	0.63	0.84	0.32	280.3	40.4	4.8	16.7	45.2
0.3%Boric acid	1.19	0.13	0.64	0.84	0.32	280.6	40.7	4.9	16.8	45.2
2%K-Citrate +0.2%Boric acid	1.20	0.14	0.64	0.85	0.33	281.0	40.7	5.0	16.8	45.3
$L.S.D_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 6: Continue

	2009 growing season									
Control	1.17	0.12	0.64	0.78	0.25	300.1	42.1	5.1	17.6	44.6
1%K-Citrate	1.17	0.12	0.65	0.78	0.25	301.2	42.3	5.1	17.6	44.7
2%K-Citrate	1.18	0.13	0.65	0.78	0.26	301.8	42.4	5.2	17.7	44.9
3%K-Citrate	1.18	0.13	0.66	0.79	0.26	302.1	42.4	5.3	17.8	44.9
0.1%Boric acid	1.18	0.13	0.65	0.78	0.26	301.5	42.5	5.2	17.8	44.7
0.2%Boric acid	1.19	0.14	0.66	0.78	0.27	301.9	42.6	5.2	18.0	44.8
0.3%Boric acid	1.20	0.14	0.66	0.79	0.27	302.5	42.8	5.4	18.1	44.8
2%K-Citrate +0.2%Boric acid	1.22	0.15	0.68	0.81	0.29	303.1	43.0	5.5	18.3	44.9
$L.S.D_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

REFERENCES

Abdel-Bary, A.M., 1999. Physiological studies on fertilization of Anna apple trees. M. Sc. Thesis. Faculty of Agriculture, Mansoura University.

Agricultural Statistical Year Book, 2009. Agricultural Research and Development Affairs, Dept. of Studies, Planning and Statistics., 22th. Table 1-26, page 66. Riyadh, Saudi Arabia.

Ahmad, W., A. Niaz, S. Kanwal and A. Rahmatullah, 2009. Role of Boron in Plant Growth: A Review. J. Agric. Res., 47(3): 329-338. ISSN: 0368-1157.

Al-Khateeb, A.A., A.M. Al-jabr and A.M. Al-jabr, 2006. Date Palm in Saudi Arabia. Date Palm Research Center, Ministry of Agriculture, Al-Hassa, Saudi Arabia (in Arabic).

Al-Hamoudi, A.H., 2006. Studies on fruit set of date palm. M. Sc. Thesis, Faculty of Agriculture, Ain Shams University. Cairo, Egypt.

AOAC (Association of Official Analytical Chemistry), 2000. Official Methods of Analysis. 17th Ed. USA. ISBN: 0-935584-42-0.

Archer, J.R., 1988. Crop Nutrition and Fertilizer Use. Farming Press Ltd. 2nd Revised edition. 278 pp. ISBN-10: 0852361750

Attalla, A.M., A.A. Etman, A.M. El-Kobbia and S.M. El-Nawam, 2007. Influence of Flower Boron Spray and Soil Application with some Micronutrients in Calcareous Soil on: 2. Yield, Quality and Mineral Content of Zaghloul Dates in Egypt. The Fourth Symposium on Date Palm in Saudi Arabia (Challenges of Processing, Marketing, and Pests Control), Date Palm Research Center, King Faisal University, Al-Hassa. 5-8 May, 2007. Abstracts Book, pp: 73.

Attia, M.M., H.A. Kassem and M.R. El-Shenawi, 2001. Effect of nitrogen and potassium fertilization on Willimams banana plants grown under calcareous soil conditions. 2. Yield and fruit quality. Alex. J. Agric. Res., 46(3): 25-34.

Baldi, E., M. Toselli, D. Seudellar, M. Taglivini and B. Marangoni, 2004. Foliar feeding of stone fruit trees. Informatore-Agrorio, 60(21): 43-46 (CAB Abs. 2004).

Behrooznam, B. and M.H. Shirzadi, 2007. The Effect of Potassium and Phosphorus on the Sugar Content and Precocious of Date Fruit. The Fourth Symposium on Date Palm in Saudi Arabia (Challenges of Processing, Marketing, and Pests Control), Date Palm Research Center, King Faisal University, Al-Hassa. 5-8 May, 2007. Abstracts Book, pp: 78.

Bouhouche, N., H.S. Al-Mazroui and A. Zaid, 2007. Fertilization Failure and Abnormal Fruit Set in Tissue Culture- Derived Date Palm (*Phoenix dactylifera* L.).Proc. IIIrd IC on Date Palm, ISHS. Acta Hort., 736: 225-232.

Callan, N.W., M.M. Thompson and M.H. Chaplin, 1978. Fruit-set of Italian prune following fall foliar and spring boron sprays. J. Amer. Soc. Hort. Sci., 103: 253–7.

Carter, M.R. (ed.) (1993). Soil Sampling and Methods of Analysis. Canadian society of Soil Science, Lewis Publishers. London, Tokyo. ISBN-10: 0873718615.

Coban, H., 2002. Investigation on the effect of potassium nitrate (KNO3) applications cluster and berry characteristics of Yavarlak cekirdeksiz grape cultivars. Anadlu., 12(2): 65-74 (CAB Abst. 2002).

Cohen, Y., R. Korchinsky and E. Tripler, 2004. Flower abnormalities cause abnormal fruit set in tissue culture-propagated date palm (*Phoenix dactylifera* L.). J. Hort. Sci. Biotechnol., 79: 1007-1013.

Desouky, I.M., A. El-Hamady, A. Hassan and A. Abdel-Hamid, 2007. Effect of Spraying Barhee Flowers with Potassium Sulphate and Boric Acid on Fruit Set, Productivity and Date Properties. The Fourth Symposium on Date Palm in Saudi Arabia (Challenges of Processing, Marketing, and Pests Control), Date Palm Research Center, King Faisal University, Al-Hassa. 5-8 May, 2007. Abstracts Book, pp: 76.

Djerbi, M., 2000. Abnormal fruiting of the date palm derived from tissue culture. Proc. Date Palm Intl. Symp., Windhoek, Namibia., pp: 73.

Embleton, T.W. and J.A. Cook, 1947. The fertilizer value of date leaf and fruit stalk pruning. Date Growers Inst., report 24: 18.

Etman, A.A., A.M. Atalla, A.M. El-Kobbia and S.M. El-Nawam, 2007. Influence of Flower Boron Spray and Soil Application with some Micronutrients in Calcareous Soil on: 1. Vegetative Growth and Leaf Mineral Content of Date Palm cv. Zaghloul in Egypt. The Fourth Symposium on Date Palm in Saudi Arabia (Challenges of Processing, Marketing, and Pests Control), Date Palm Research Center, King Faisal University, Al-Hassa. 5-8 May, 2007. Abstracts Book, pp: 72.

Gauch, H.G. and W.M. Dugger, 1954. The physiological action of boron in higher plants: A review and interpretation. Bull. Md. Agric. Exp. Station, A 80 (Technical).

Gurevich, V., U. Lavi and Y. Cohen, 2005. Genetic variation in date palms propagated from offshoots and tissue culture. J. Amer. Hort. Sci., 130(1): 46-53.

Harhash, M.M. and G. Abdel-Nasser, 2007. Impact of Potassium Fertilization and Bunch Thinning on Zaghloul Date Palm. The Fourth Symposium on Date Palm in Saudi Arabia (Challenges of Processing, Marketing, and Pests Control), Date Palm Research Center, King Faisal University, Al-Hassa. 5-8 May, 2007. Abstracts Book, page 70.

Hassanein, H., 2004. Effect of calcium and potassium foliar application on post harvest peach fruit quality. Ph. D. Thesis. Faculty of Agriculture, Cairo University, Egypt.

Jackson, M.L., 1973. Soil Chemical Analysis. Prentice-Hall, Inc. India.

Katyal, J.C. and N.S. Randhawa, 1983. Micronutrients. FAO Fertilizer and Plant Nutrition Bulletin, No. 7. Food and Agriculture Organization, United Nations. ISBN-10: 9251014450.

Khayyat, M., E. Tafazoli, S. Eshghi and S. Rajaee, 2007. Effect of Nitrogen, Boron, Potassium and Zinc on Yield and Fruit Quality of Date Palm. American-Eurasian J. Agric. & Environ. Sci., 2(3): 289-296. ISSN: 1818-6769.

Klute, A. (ed.), 1986. Methods of Soil Analysis. Part 1: Physical and Mineralogical Methods. 2^{ed}. Agronomy Series, NO. 5. American Society of Agronomy, Inc. and Soil Science Society of America, Inc., Madison, WI. ISBN-10: 0891188118.

Marcus-Wyner, L. and D.W. Rains, 1982. Nutritional disorders of cotton plants. Commun. Soil Sci. Plant Anal., 13(9): 685-736. DOI: 10.1080/00103628209367306.

Marschner, H., 1995. Mineral Nutrition of Higher Plants. Academic Press, London. ISBN: 0124735436.

Mengel, K. and E.A. Kirkby, 2001. Principles of Plant Nutrition. 5th rev ed., Kluwer Academic Publishers (United States). ISBN-10: 1402000081.

Moghimi, A. H., 2007. Effects of Micronutrients on Quality and Quantity of Yield Date Palm cv. Berhi in Hormozgan. The Fourth Symposium on Date Palm in Saudi Arabia (Challenges of Processing, Marketing, and Pests Control), Date Palm Research Center, King Faisal University, Al-Hassa. 5-8 May, 2007. Abstracts Book, pp: 83.

Murphy, J. and J.P. Riely, 1962. A modified single solution method for the determination of phosphorus in natural water. Anal. Chem. Acta., 27: 31-36.

Price, C.A., H.E. Clark and E.A. Funkhouser, 1972. Functions of Micronutrients in Plants. In: Micronutrients in Agriculture, Mortvedt *et al*., (Eds.). Soil Science Society of America, Book Series, No 4. Madison, Wisconsin, USA, pp: 231-239. ASIN: B000H6PVEM.

Rerkasem, B., 1996. Boron and plant reproductive development. In: Sterility in Wheat in Sub-tropical Asia: Extent, Causes and Solutions. Rawson, H. M. and K. D. Subedi (eds.). pp: 32-35. ACIAR Proc. No. 72.

Saleh, M.M.S. and E.A. El-Monem, 2003. Improving the productivity of "Fagri Kalan" mango trees grown under sandy soil conditions using potassium, boron and sucrose as foliar spray. Annals of Agric. Sci., Ain Shams Univ., 48(2): 747-756.

SAS Institute Inc., 2001. The SAS System for Windows. SAS user's guide: Statistics. Version 8. SAS Inst., Inc. Cary, NC.

Shahin, M., 2007. Effect of Potassium Fertilization on Growth, Leaves Nutrient Content, and Yield of "Khalas" Date Palm in Al-Hassa Oasis (K.S.A). The Fourth Symposium on Date Palm in Saudi Arabia (Challenges of Processing, Marketing, and Pests Control), Date Palm Research Center, King Faisal University, Al-Hassa. 5-8 May, 2007. Abstracts Book, pp: 77.

Steel, R.G. and J.H. Torrie, 1980. Principles and Procedures of Statistics. 2nd Ed., McGraw-Hill Book Company, New York, USA. ISBN: 13-9780070609266.

Talaie, A., M. T. Badmahmoud and M.G. Malakout, 2001. The effect of foliar application of N, B and Zn on quantitative and qualitative characteristics of olive fruit. Iranian Journal of Agricultural Science, 32(4): 727-736 (CAB Abs. 2002).

Varughese, A., 2000. Mass propagation of date palm through tissue culture: An efficient method by SAPAD. Proc. Date Palm Intl. Symp., Windhock, Namibia, pp: 65-67.

Westover, F. and J. Kamas, 2009. Investigation of Spray Timing of Boron and Effects of Micro-nutrient Sprays on Yields of 'Blanc du Bois' Wine Grapes. Proceedings of the Texas Viticulure& Enology Research Symposium. June 2-3, 2009, Granbury, Texas.

Wojcik, P. and M. Wojcik, 2003. Effect of boron fertilization on conference pear tree vigor, nutrition, and fruit yield and storability. Plant and Soil, 256(2): 413-421. DOI: 10.1023/A:1026126724095

Wolf, B., 1982. A comprehensive system of leaf analysis and its use for diagnosing crop nutrients status. Commu. Soil Sci., Plant Anal., 13(12): 1035-1059. DOI: 10.1080/00103628209367332.

Zaid, A. and E.J. Arias-Jimenez, 2002. Date palm cultivation. FAO Plant Production and Protection Paper, FAO 156. Rev.1. FAO, Rome Italy. ISSN: 0259-2517.