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EFFECT OF POTASSIUM FERTILIZATION ON YIELD, FRUIT QUALITY AND LEAF ELEMENTAL CONTENT OF "PEYUAN" BER (*Ziziphus mauritiana* LAM.) CULTIVAR

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ABSTRACT

A field experiment was conducted on ten years old "Peyuan" ber (*Ziziphus mauritiana* Lam.) cultivar during 2005 and 2006 seasons. The trees were grown in loamy sand soil at the Agricultural Research and Experiment Station (Dirab), College of Food and Agricultural Sciences, King Saud University, Riyadh, Saudi Arabia. The aim of the present study was to investigate the effect of potassium fertilization at rates of 0, 500, 750, 1000 and 1250 g K_2O /tree / year on yield, fruit quality and leaf elemental contents. The obtained results for both seasons revealed that K treatments significantly increased fruit yield. Potassium fertilization significantly increased the average fruit weight, size, length, diameter, flesh weight percentage over the control in 2005 and 2006 seasons. The highest values were obtained with 750 g K_2O /tree/year in both seasons. The control trees gave the lowest percentage of fruit grade 1 compared to K treatments in both seasons. However, 750 g K_2O /tree/year treatment had a highest percentage of fruit grade 1 (44.53 and 58.03% in both seasons, receptivity) and values of fruit flesh firmness. Treatments of 1000 and 1250 g K_2O /tree/year in both seasons, gave the highest values of fruit V.C compared to the control, 500 and 750 g K_2O /tree. The acidity percentage in the fruit juice decreased significantly among the potassium treatments in both seasons. The percentage of total soluble solids (TSS), reducing, non–reducing and total sugars followed nearly similar trends as they were affected significantly by potassium treatments in both seasons. Thus, it is obvious that the highest mentioned parameters were found in fruits collected from 750 and 1000 g K_2O /tree/year treatments in both seasons. On the other hand, the least values always resulted from control (zero g K_2O /tree/year) treatment in both seasons. Generally, applying K at 750 g K_2O /tree/year improved yield, fruit quality and nutrient uptake. Thus, such treatment could be the promising treatment for "Peyuan" ber cultivar grown under similar conditions.

Keywords: potassium, ber, *Ziziphus mauritiana* Lam., fruit quality, leaf elemental contents

INTRODUCTION

Ber or Chinese apple (*Ziziphus mauritiana* Lam.) belongs to the Rhamnaceae family and originated in Central Asia (Pareek, 2001). Ber trees can withstand extremely high summer temperatures (Grice, 1998) and they are highly drought tolerant (Fact sheet, 2001). Moreover, trees are saline tolerant and can grow on poor degraded land (Pandey *et al.*, 1993 and Fact sheet, 2001). Tree nutrition is an important factor for a successful orchard operation and it can be controlled by proper fertilization program. Ber fruits remove large amounts of K compared with other nutrients. A ber tree removes from the soil, 142 to 191 g N, 59 to 87 g P and 467 to 684 g K on average during a single growing season (Mehrotra *et al.*, 1987). According to

Singh *et al.*, (1995), 43.8 g N, 7.5 g P, 101.2 g K, 4.5 g Ca and 22.7 g Mg are removed by 100 kg harvest of fruits. A shortage of K can result in loss of crop yield and quality (Faust 1989 and Bob 2006). Many investigators proved the importance of K fertilization. Lal & Dhaka, (2003) reported that K improves the growth, yield and fruit quality of ber cv. Umran. Other investigations in olive (Mustafa *et al.*, 2000 and El- Shazly & Abdel- Nasser, 2001), in date palm (Harhash, 2000 and Khayyat *et al.*, 2007), in orange (Shawky *et al.*, 2000 and Quaggio *et al.*, 2006), in banana (Hongwei el al., 2006) and in pomegranate (Al-Obeed, 2001) reported that K fertilization increased the yield and improved fruit quality.

The objective of this study is to investigate the effect of potassium fertilizer on yield, fruit quality and leaf elemental content of ber "Peyuan" (*Ziziphus mauritiana* Lam.) cultivar.

MATERIALS AND METHODS

The present study was conducted during 2005 and 2006 growing seasons in order to study the effect of potash fertilization on yield, fruit quality and leaf elemental content of "Peyuan"ber (*Ziziphus mauritiana* Lam.) cultivar. Peyuan cv. was introduced from china and no specific research on its fertilization has been conducted to the knowledge of the authors. Ten years old orchard trees were budded on (*Ziziphus spina-christi* Lam.) rootstock, grown in the Agricultural Research and Experiment Station (Dirab), College of Food and Agricultural Sciences, King Saud University, Riyadh, Saudi Arabia. The trees were planted at seven meters apart on loamy sand soil. Some physical and chemical properties of the soil are presented in Table (1). The analysis of irrigation water is presented in Table (2).

Table (1): Some physical and chemical analysis of orchard soil at a depth of 0-30 cm

Parameters	Values
Particle size distribution, %	
Sand	85
Silt	10
Clay	5
Texture class	Loamy sand
Organic matter content (%)	0.25
$CaCO_3$ content (%)	32.30
pH	7.94
EC_e (dS/m)	1.11
Soluble cations (meq/L)	
Ca^{2+}	7.00
Mg^{2+}	1.25
Na^{+}	2.17
K^{+}	1.62
Soluble anions (meq/L)	
$CO_3^{-}+HCO_3^{2}$	1.58
Cl^{-}	2.70
SO_4^{2-}	6.47

Table (2): The analysis of irrigation water

Parameters	Values
pH	7.10
EC_w (dS/m)	1.91
Soluble cations (meq/L)	
Ca^{2+}	7.75
Mg^{2+}	6.50
Na^{+}	9.43
K^{+}	0.69
Soluble anions (meq/L)	
$CO_3^{-}+HCO_3^{2-}$	2.75
Cl^{-}	8.00
SO_4^{2-}	7.84

Twenty-five trees were chosen as uniform as possible in growth and vigor. The trees were subjected to the same cultural practices commonly adopted in the orchard. In addition, potassium chemical fertilizers were not applied to the experimental trees several years before the initiation of the present experiment. The ordinary fertilization program was 5 Kg of chicken manure per tree added during winter, 1Kg/tree of triple calcium super phosphate (45% P_2O_5) broadcast on the soil surface throughout the whole area during December and 5 Kg ammonium sulphate/tree (20% N) broadcast on the soil surface through the whole area during July, September, October, February and March at equal doses.

The study comprised the effect of potassium fertilizer. Five levels of potassium sulphate (48-52% K_2O) were applied as follows: Zero (control), 500, 750, 1000 and 1250 g K_2O /tree yearly at three equal doses in October (after fruit set), February and March for all treatments. The potash fertilizer was broadcasted on soil surface 1.25 m apart from the tree trunk.

Fruits were harvested at the first week of April. Yield per tree was recorded. Sample of 50 fruits were randomly collected from each tested tree (five replicates in each treatment) for fruit quality determinations. In each fruit sample, fruit weight, volume, length, diameter and seed weight were determined. The fruit firmness (kg/cm²) was measured at two equatorial points on opposite sides by using the fruit hardness tester (FHR-5) "Nippon optial works co., LTD- Tokyo, Japan". The percentage of total soluble solids (TSS) was determined in fruit juice using BRX-242 digital refractometer. Juice acidity percentage (estimated as citric acid equivalent) was determined by titration with NaOH and phenolphthalein indicator. Vitamin C (Ascorbic acid) was determined by titration with 2, 6 dichlorophenol-endophenol blue dye and expressed as ascorbic acid (mg per 100 g pulp). Reducing, non–reducing and total sugars were determined according to (A.O.A.C., 1986). Fruits were graded into two levels based on size and colour based on the report of Pareek (2001) was used.

At mid October of each season, samples of 100 leaves (one year old) from each tree above fruiting zone were collected. Each sample was collected randomly at a constant height and at all directions of the trees. Leaf samples were washed with tap water, distilled water, air-dried and oven dried at 65°C for 72 hr. The dried samples were grinded 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) leaf contents were determined by atomic absorption Spectrophotometer (Carter, 1993).

The treatments were arranged in Randomized Complete Design with five replications for each treatment. All collected data were subjected to statistical analysis of variance according to SAS Software (SAS Institute Inc., 1996).

RESULTS AND DISCUSSION

Yield

The data presented in Table (3) revealed that K fertilization markedly increased fruit yield (Kg/tree) compared with control, in both seasons. Moreover, increasing K rate caused a gradual increase in fruit yield. Such increments compared with control were 22.46, 37.77, 44.23 and 49.25% for K rates of 500, 750, 1000 and 1250 g K_2O /tree /year, respectively, in the first season. Meanwhile, in the second season, they were 23.27, 39.95, 45.55 and 51.79 % respectively. The yield increase with K application may be attributed to the role of K in increasing root growth and improving drought tolerance, building cellulose and lodging reduction, enhancement of many enzyme actions, aids in photosynthesis and food formation, helps translocation sugars and starches, increasing protein content of plants and retarding crop diseases and nematodes (Bob 2006). These results may gain support from those obtained by Lal & Dhaka (2003) on ber, Mustafa *et al.* (2000), El-Shazly and Abdel- Nasser (2001) on olive, Harhash (2001) and Khayyat *et al.* (2007) on date palm and Shawky *et al.* (2000) and Quaggio *et al.* (2006) on orange, and Hongwei *et al.* (2006) on banana. They reported that K application increased yield and fruit quality.

Fruit physical characteristics:

The effects of K fertilization on some fruit physical properties are presented in Table (3). Potassium fertilization significantly increased the average fruit weight over control in 2005 and 2006 seasons. These increases in fruit weight over the control were 18.75, 35.91, 28.55 and 21.04 % in the first season for 500, 750, 1000 and 1250g K_2O /tree/year, respectively. The corresponding values for the second season were 21.94, 38.23, 25.14 and 23.99 %, respectively. The highest fruit weight values were obtained with 750 g K_2O /tree/year in both seasons. No significant difference was found between treatments 1000 and 1250 g K_2O /tree/year. The tow treatments decreased fruit weight as compared with the 750 g K_2O /tree/year in both seasons. Such decrease may be due to increasing fruit yield (Table 3).

The fruit length and diameter were significantly increased by potassium fertilization compared to the control during 2005 and 2006 seasons (Table 3). These increases were higher with 750 g K_2O /tree/year treatment in both seasons. It was, also, found that no significant differences existed among treatments 1000 and 1250 g K_2O /tree/year in both seasons.

Potassium fertilizer treatments significantly increased the fruit volume compared to the control during 2005 and 2006 seasons (Table 3). The trend was found to be the same as fruit weight. Maximum increase in fruit volume was obtained at 750 g K_2O/tree/year treatment in both seasons.

The present results indicated that, in both seasons, values of flesh weight percentage significantly increased with the applied potassium fertilizer (Table 3). Meanwhile, no significant differences were found among 500, 750, 1000 and 1250 g K_2O /tree/year treatments in both seasons.

It is obvious from Table (3) that the fruit grade 1 percentage in the fruit yield was significantly affected by K treatments in both seasons. The control trees gave the lowest percentage of fruit grade 1 compared to K treatments in both seasons. However, 750 g K_2O /tree/year treatment had highest percentage of fruit grade 1 (44.53 and 58.03 in both seasons, receptivity).

The data in Table (3) also indicated that, in both seasons, 750 and 1000 g K_2O/tree/year significantly increased values of fruit flesh firmness.

Such improvement in fruit quality may be attributed to the role of K in many important regulatory roles in the plant. Potassium is essential in nearly all processes needed to sustain plant growth and reproduction. It is known to activate at least sixty enzymes involved in plant growth. Moreover, this may be the most important function in the plant. Potassium is also known as the quality nutrient because of its important effects on quality factors such as, size, shape color, taste, shelf life and other quality characters (Faust, 1989 and Bob, 2006). These results are in harmony with those found by Lal & Dhaka (2003) on ber, Mustafa *et al.* (2000), El- Shazly & Abdel- Nasser (2001) on olive, Harhash (2001) and Khayyat *et al.* (2007) on date palm and Shawky *et al.* (2000), Quaggio *et al.* (2006) on orange, and Hongwei *et al.* (2006) on banana. They reported that K application improves fruit quality.

Table (3): Effect of K application on fruit physical characteristics of "Peyuan" ber cultivar during 2005 and 2006 seasons.

Treatment k_2O/tree/ year (g)	Yield (Kg)	Fruit weight (g)	Fruit length (mm))	Fruit diameter (mm)	Fruit volume (cm^3)	Flesh weight (%)	Fruit Grade 1 (%)	Flesh firmness (kg/cm^2)
2005								
(0) Control	69.68	22.67	26.32	20.57	24.2	89.10	36.10	10.85
500	85.33	26.92	29.62	22.09	27.98	90.92	40.40	11.20
750	96.00	30.81	34.05	26.08	33.95	92.32	55.67	12.55
1000	100.50	28.72	30.77	24.61	30.00	91.74	44.53	12.25
1250	104.00	27.44	31.67	25.51	29.50	92.09	43.23	11.00
$LSD_{0.05}$	5.82	1.65	2.03	1.79	2.32	1.60	4.77	0.65
2006								
(0) Control	67.33	22.47	27.11	22.05	23.44	89.95	32.8	10.50
500	83.00	27.40	31.82	25.68	28.92	92.56	42.83	10.80
750	94.23	31.06	36.66	27.72	34.21	94.01	58.03	12.95
1000	98.00	28.12	32.77	24.89	31.67	93.27	46.33	12.15
1250	102.20	27.86	31.97	25.93	29.85	93.68	47.13	11.30
$LSD_{0.05}$	4.29	1.55	2.30	1.63	1.63	1.63	5.67	0.55

Fruit chemical characteristics:

Data of both experimental seasons clearly showed that soluble solids content (SSC) of ber fruit juice was noticeably affected by the different potassium fertilization rates (Table, 4). It is obvious that 750 and 1000 g K_2O /tree/year significantly encouraged and promoted the SSC percentage over the control, 500, and 1250 g K_2O /tree/year in both seasons. Also, it is worthy to mention that the lowest values in this respect came from control (zero g K_2O /tree/year) treatment in both seasons.

Results of the present study demonstrated that fruit acidity percentages in the fruit juice was significantly decreased among the potassium treatments in both seasons (Table, 4). The highest fruit acidity percentage in fruit juice was recorded in the control treatment in both seasons as compared with potassium fertilization. Meanwhile, no significant differences were found between potassium treatments in both seasons.

The effect of K treatments on Vitamin C (V.C) content of "Peyuan" ber fruit are presented in Table (4). The data clearly revealed that increasing K rates increased fruit V.C content. Treatments receiving 1000 and 1250 g K_2O /tree/year in both seasons, gave the highest values of fruit V.C compared with the control or 500 and 750 g K_2O /tree/year.

The obtained data revealed that the "Peyuan" ber fruit content of reducing, non–reducing and total sugars followed nearly similar trends and were significantly affected by potassium treatments in both seasons (Table, 4). Thus, it is obvious that the highest mentioned parameters were found in fruits collected from 750 and 1000 g K_2O /tree/year treatments in both seasons. On the other hand, the least values always resulted from control (zero g K_2O /tree/year) treatment in both seasons. Improving fruit chemical characteristics due to potassium fertilization plays a vital role in photosynthesis and helps in translocation of sugars and starch (Faust, 1989 and Bob, 2006). Similar findings were reported by Lal & Dhaka (2003) on ber, Mustafa *et al.* (2000), Harhash (2001) and Khayyat *et al.* (2007) on date palm and Shawky *et al.* (2000) and Quaggio *et al.* (2006) on orange, and Hongwei *et al.* (2006) on banana. They reported that K application improved fruit quality.

Table (4): Effect of K application on fruit chemical characteristics of "Peyuan" ber cultivar during 2005 and 2006 seasons.

Treatment K_2O/tree/year (g)	SSC (%)	Acidity (%)	V.C mg/100 ml juice	Reducing sugars (%)	Non-reducing sugars(%)	Total sugars (%)
2005						
(0) Control	12.13	0.48	42.23	7.73	2.20	9.93
500	13.00	0.40	45.58	9.10	2.50	11.60
750	14.53	0.38	49.03	9.70	3.07	12.77
1000	14.70	0.36	59.60	9.90	3.10	13.00
1250	12.93	0.37	62.20	8.40	2.57	10.97
$LSD_{0.05}$	0.40	0.05	3.03	0.56	0.45	0.53
2006						
(0) Control	11.17	0.50	39.99	6.78	2.38	9.16
500	12.73	0.40	42.66	8.27	2.38	10.65
750	14.13	0.42	55.54	9.87	2.90	12.77
1000	14.50	0.37	61.22	9.60	2.93	12.53
1250	12.40	0.37	63.01	8.20	2.23	10.43
$LSD_{0.05}$	0.46	0.07	4.77	0.41	0.37	0.41

Leaf elemental contents:

Data presented in Table (5) show the effect of K treatments on leaf mineral content of "Peyuan" ber trees. It is noticed that, K fertilizer markedly increased leaf contents of N, K, Mg, Fe, Mn, Cu and Zn and markedly decreased leaf Ca content. Meanwhile P content was not affected by K applications. Generally, the pronounced effect of K on leaf mineral contents was clear at high K level. Increasing leaf nutrient contents with K fertilization may be due to the improvement of vegetative growth and consequently increase in nutrient absorption. These results are in harmony with those obtained by Perica *et al.* (1994), Loupassaki *et al.* (1997), Abdel-Nasser and El-Shazly (2001). Decreasing leaf Ca content with increasing K application rate may be due to the fact that more absorption of K ion may leads to antagonistic effect of such element with Ca (Epestein, 1972).

Generally, applying potassium fertilizer at 750 g K_2O/tree/year improved yield, fruit quality and nutrient uptake. Thus, such treatment could be a promising treatment for "Peyuan" ber cultivar grown under similar conditions.

Table (5): Effect of K application on leaf elemental content of "Peyuan" ber cultivar during 2005 and 2006 seasons.

Treatment K_2O/tree/year (g)	Macronutrients (%)					Micronutrients (mg/Kg)			
	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn
2005									
(0)Control	2.12	0.19	1.27	1.93	0.27	132.2	38.8	12.8	21.9
500	2.25	0.20	1.45	1.78	0.31	138.4	42.8	14.7	23.7
750	2.28	0.22	1.64	1.62	0.32	141.5	47.0	17.8	27.4
1000	2.30	0.23	1.91	1.50	0.36	147.3	49.2	20.8	30.9
1250	2.32	0.21	1.85	1.41	0.41	150.6	51.5	22.1	32.6
$LSD_{0.05}$	0.03	N.S	0.08	0.06	0.02	2.5	3.3	2.2	2.8
2006									
(0)Control	2.23	0.18	1.31	1.87	0.31	135.3	34.4	13.3	22.1
500	2.26	0.21	1.48	1.80	0.35	141.8	41.9	16.0	24.2
750	2.30	0.20	1.69	1.61	0.39	146.2	48.3	18.5	29.6
1000	2.35	0.21	1.86	1.46	0.42	150.5	52.1	21.3	31.8
1250	2.50	0.22	1.94	1.38	0.46	153.8	54.6	23.1	33.1
$LSD_{0.05}$	0.05	N.S	0.06	0.05	0.03	2.8	3.4	1.8	2.7

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تأثير التسميد البوتاسى على محصول و صفات جودة الثمار و محتوى الأوراق من العناصر في السدر الصيني صنف "بايون"

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قسم الإنتاج النباتي – كلية علوم الأغذية و الزراعة- جامعة الملك سعود

أجريت تجربة حقلية خلال موسمي ٢٠٠٥ و ٢٠٠٦ على أشجار السدر الصيني (*Ziziphus mauritiana* Lam) صنف "بايون" عمرها ١٠ سنوات نامية في أرض رملية غرينية في مزرعة محطة الأبحاث و التجارب الزراعية - ديراب – كلية علوم الأغذية و الزراعة – جامعة الملك سعود. الغرض من الدراسة هو معرفة تأثير التسميد البوتاسى على المحصول – صفات جودة الثمار و محتوى الأوراق من العناصر الغذائية. أضيف التسميد البوتاسى بمعدلات صفر(المقارنة) , ٥٠٠ , ٧٥٠, ١٠٠٠ و ١٢٥٠ جرام من أكسيد البوتاسيوم/ شجرة/ سنة في صورة سلفات بوتاسيوم (٤٨% بو٢ا) علي ٣ دفعات في شهر أكتوبر (بعد العقد) و فبراير و مارس في كلا موسمي التجربة. أظهرت النتائج أن معدلات التسميد البوتاسي أدي إلي زيادة معنوية في محصول الأشجار من الثمار. التسميد البوتاسى أدى إلي تحسين صفات جودة الثمار الفيزيائية (وزن و حجم الثمرة – طول و قطر الثمرة – النسبة المئوية من اللحم). كما أدى التسميد البوتاسي إلي زيادة نسبة الثمار من الرتبة الأولى بالإضافة إلي تحسين صلابة الثمار. تشير النتائج إلى زيادة محتوي الثمار من المواد الصلبة الذائبة و السكريات المختزلة – وغير المختزلة و الكلية بالتسميد البوتاسي بينما انخفضت نسبة الحموضة. أدت المعاملات بالبوتاسيوم إلى زيادة محتوي الأوراق من البوتاسيوم و النتروجين و الحديد و المنجنيز و النحاس و الزنك بينما حدث نقص الكالسيوم لكن لم يتأثر الفوسفور . و بصفة عامة فأن المعاملة بالبوتاسيوم بتركيز ٧٥٠ جرام من أكسيد البوتاسيوم/ شجرة/ سنة أعطت أفضل النتائج من حيث محصول مناسب وتحسين صفات جودة الثمار في كلا موسمي التجربة و يمكن التوصية بهذه المعاملة تحت الظروف المماثلة لهذه التجربة.