Effect of Levels and Methods of Potassium and Phosphorus Fertilization on Yield, Fruit Quality and Chemical Composition of "Khalas" Date Palm Cultivar

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Abstract: The present study was carried out during 2010 and 2011 seasons at the Research and Agricultural Experimental Station, King Saud University, Saudi Arabia in order to study the effect of potassium and phosphorus fertilization rates applied either alone or in combinations with each other on leaf mineral content, yield and fruit quality of Khalas date palm cultivar. Potassium and phosphorus rates were added in either; one, two or three equal doses in 15th of February (before flowering), 15 th of April (after fruit set) and 15 th of May (during fruit maturity). The results showed that potassium and phosphorus fertilization increased the fruit set and yield and improved the fruit physical characteristics (fruit weight, volume, length and diameter) at beser stage, and chemical characteristics (TSS, acidity and sugars contents) at Tamer stage, especially with high levels of potassium fertilization. The high level of potassium fertilization increased the pinnae N, P, K and Fe contents, while decreased the Zn and Mn contents. Thus, it is recommended to add the high level of potassium (2 Kg potassium sulphate) and phosphorus (1.5 Kg calcium super phosphate) at three and two equal doses, respectively to increase the yield and fruit quality of "Khalas" date palm grown under the present conditions.

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1. Introduction:

Date palm (*Phoenix dactylifera*, L.) is one of the most important fruits in the world and Saudi Arabia. According to FAO (2010), Saudi Arabia is considered the third country of the top ten date producers (982546 tones). Khalas date palm is the most important cultivar in Saudi Arabia.

Several investigators studied the effect of potassium and phosphorus fertilization on fruit set, yield, fruit quality and leaf mineral content of different date palm varieties. Nitrogen, phosphorus and potassium are the three most needed nutrients by palms, which are commonly met through fertilizers. When applying fertilizers to the palms, our goal is to maximize nutrient uptake by the palms from fertilizers for optimum growth and yield (Tung et al., 2009). Soil test-based fertility management is an effective tool for increasing productivity of agricultural soils that have high degree of spatial variability resulting from the combined effects of physical, chemical or biological processe. However, major constraints impede wide scale adoption of soil testing in most developing countries (Goovaerts, 1998). K and Mg also influences many of the processes that are important for the formation of yield in plants such as water economy, synthesis of carbohydrates and the transport of assimilates (Mengel and Kirkby, 1982).Potassium play a key role in N uptake and translocation from roots to vegetative growth (Cushnahan et al. 1995). Sinclair *et al.* (1981) who found that the 1100 g N and 800 g P_2O_5 for each fruitful tree caused the best yield and fruit quality. Also, Bacha and Abo-Hassan (1982) showed that chemical fertilizers increased the yield of trees as compared with the organic manure. Some of the fruit physical and chemical characteristics were affected by the chemical fertilizers. Soil fertilization did not significantly affect the fruit N, P, K, Ca and Mg content. Bliss and Mathez (1983) found that the best fertilizer recommendation as 930 g N and 620 g P_2O_5 for each tree in each year. As well as, EI-Hammady *et al*. (1991), Shahrokhnia, (1992), Sabbah (1993), Bamiftah (2000) found that the highest yield and fruit quality of dates were obtained by adding potassium to palm trees. Likewise, Kassem *et al*. (1997) reported that potassium fertilizer increased the leaf N and K content of Zaghloul date palm. Additionally, Soliman and Osman (2003) and Osman (2010) reported that the N_1K_1(1.5+1.5) kg/palm gave the highest fruit diameter,fruit TSS% and total sugars content,and added that the leaf N and K content increased, while Fe and Zn decreased with increasing the N and K rates in both seasons. Also, Fahim and Saleh (2007) showed that the phosphorus and potassium fertilizer caused meaningful increase in yield and improvement fruit quality. In addition, Shahin (2007) found that, the best rate of potassium fertilization for the best growth, yield and leaf N, P and K content was 4.5 kg /palm / year. The results,

also revealed that the application of K fertilizer at two equal doses in May and December or at three equal doses in March, May and December were the better under Al-Hassa Oasis (K.S.A) conditions, on a 20 years-old "Khalas" date palm, grown on sandy loam soils.

The successful orchard management practices are directed toward obtaining a suitable yield with good fruit quality. The most important cultural practices in date palm orchards is fertilization. Recommendations of the scientific meetings for data palm research stressed the importance of fertilization to improve the productivity and fruit quality. Fertilization of dates is necessary for reasons to insure adequate flowering and to relieve the alternate bearing for the successive year and to obtain larger fruit size and quality. It has been well known that the nutrient requirements of the date palms could be fulfilled through the fertilizers application for the interplant crops. Therefore, this investigation was carried out to study the effect of level and application time of potassium and phosphorus fertilizer on fruit set, yield, quality and leaf mineral content of " Khalas" date palm cultivar grown in Riyadh region.

2. Materials and Methods:

This study was carried out during 2010 and 2011 seasons at the Research and Agricultural Experimental Station, King Saud University, Saudi Arabia in order to study the effect of potassium and phosphorus fertilization rates applied either alone or in combinations with each other on yield, fruit quality and leaf mineral content, of Khalas date palm cultivar. Tow levels of potassium sulphate; 50% K_2O (K1= 1kg; K2= 2 kg) and tow levels of triple supper phosphate;45% P_20_5 (P1= 1 kg; P2= 1.5 kg) were added in either one dose, two doses or three equal doses in 15th of February 15 (before flowering), 15 th of April (after fruit set) and 15 th of May (during fruit maturity). For this study, thirty trees were chosen as uniform as possible.The trees were planted at a spacing of 7 x 7 meters and grown in loamy calcareous soil. Before experiment had been conducted in the 1st season, mechanical and chemical analysis of orchard soil and water irrigation were done as shown in Table (1). The treatments were as follows: Female palms with similar vigor, height, pollen source and age (10 years old) were selected and subjected to the normal cultural practices applied for date palms (10 bunches /palm) and one level of actual nitrogen (1000g/palm) from ammonium sulphate (20.6%N). Ten soil application treatments were arranged in a completely randomized design with three replicates (1 replicate = 1 palms) per treatment (i.e. 10×3 = 30 palm).

Table 1: Some physical and chemical characteristics of soil and irrigation water used for the present study

Parameters	Value	Parameters	soil	Irrigation Water
Sand (%)	75.10	pH	---	6.87
Silt (%)	12.00	EC (dS/m)	---	1.68
Clay (%)	12.90	**Cations**	**(meq/l)**	**(meq/l)**
Textural class	**Sandy loam**	Ca^{2+}	3.30	7.00
Organic matter (%)	0.40	Mg^{2+}	2.50	3.60
pH	7.50	Na^{+}	5.60	9.80
EC (dS/m)	1.00	K^{+}	0.30	0.50
Calcium carbonates (%)	18.79	**Anions**	**(meq/l)**	**(meq/l)**
Total N ppm	14	HCO_3	2.60	5.70
P ppm	18.20	$CO_3^{=}$	nd	nd
K ppm	92.00	Cl^{-}	5.00	8.00
----	----	SO_4	3.60	7.30

The treatments were as follows:

T1 = Control, without any PK mineral fertilizer(P0K0).
T2 = 1.0 Kg P + 2.0Kg K at one dose (P1K2D1).
T3 = 1.0 Kg P + 2.0Kg K at two doses (P1K2D2).
T4 = 1.0 Kg P + 2.0Kg K at three doses (P1K2D3).
T5 = 1.0 Kg P + 1.0Kg K at one dose (P1K1D1).
T6 = 1.0 Kg P + 1.0Kg K at two doses (P1K1D2).
T7 = 1.0 Kg P + 1.0Kg K at three doses (P1K1D3).
T8 = 1.5 Kg P + 2.0 Kg K at one dose (P2K2D1).
T9 = 1.5 Kg P + 2.0Kg K at two doses (P2K2D2).
T10 = 1.5 Kg P + 2.0Kg at three doses (P2K2D3).

The fruits were harvested at beser stage at the last week of July and tamer stage was harvested in mid August in both seasons and following characters were determined:

Fruit set percentage = Number of fruits x 100 / Total number of flowers

Yield:

The average fruit yield/date and bunch weight were recorded in kilograms. **Fruit physical characteristics:** At beser stage a sample of ten strands were randomly collected from each replicate in both seasons for each treatment and packed in boxes and transported immediately to the laboratory to determine the fruit physical characteristics (i.e) fruit weight, seed weight and fruit flesh weight (in gm), Fruit volume (cm^3) and fruit dimensions (fruit length and fruit diameter, in cm).

Fruit chemical characteristics:

Chemical properties of fruits at tamer stage namely total soluble solid (TSS %), fruit acidity (%), sugar content (reducing, non-reducing and total sugar) and moisture content, were determined according to A.O.A.C., 1995.

Leaf mineral contents:

A leaf sample of three consecutive leaves located just below the fruiting zone (about two years old) was taken at random from each replicate in mid-October.Leaf samples were washed with tap water, rinsed twice in distilled water and dried in air drying oven at 70 ◦C. Dried leaves were grounded and digested with H_2O_2 and H_2SO_4 according to Evanhuis and De Waard (1980). Suitable aliquots were taken for the determination of the mineral content; Nitrogen was determined by the Kjeldahl method (AOAC, 1995). Phosphorus was determined by ascorbic acid method according to Murphy and Riley (1962). Potassium was determined by flame photometer. Fe, Zn and Mn, contents were measured using an atomic absorption spectrophotometer (Model 305B). The concentrations of N, P, and K were expressed as percentages, while Fe, Zn and Mn as parts per million (ppm) on dry weight basis.

Statistical analysis:

The experimental design was randomized complete block including four treatments. Data obtained throughout this study were statistically analyzed using the analysis of variance method as reported by Snedecor and Cochran, 1980, and the differences between means were differentiated by using Duncan's range test.

3. Results and Discussion

Fruit set percent and yield:

The results obtained in Table (2) showed that, fruit set of " Khalas" date palm cultivar was higher by the application of T10,T8 and T2 treatments in the first season (72.92,70.09 and 69.96 %, respectively), while in the second season T10 treatment gave the highest fruit set percent only. However T1 gave the lowest value (47.15 and 42.45 %) during two seasons of the study, respectively, compared to the other treatments. Concerning the average bunch weight, the data obtained in Table (2) indicated that the T4 treatment gave the highest bunch weight in the first and second seasons (14.40 and 14.34 Kg, respectively) however, the T1 treatment gave the lowest values. The data in Table (2) also showed that the T4 treatment gave the highest yield as kg/tree of "Khalas" date palm, while T1 treatment gave the least values during two seasons of the study. These increment in date palm yield by K treatments may be attributed to the physiological role of potassium in enhancing many metabolic processes such as carbohydrate formation, translocation and accumulation. Archer (1985) reported that translocation of photosynthates depended on cell potassium concentration. The obtained results are in close agreement with those found by EI Hammady *et al*. (1991), Shawky et al. (1999), Bamiftah(2000), Osman (2010), Shahin (2007) Al-Kharusi *et al*. (2007) studied the effect of potassium fertilization on yield, and found that the K applied at three doses in March, June and September gave the highest palm yield, bunch weight.

Fruit physical characteristics:

Fruit weight (g):

Data presented in Tables (3 &4) showed that the average fruit weight of 'Khalas' date palm at beser stage was significantly higher in trees treated by T4 treatment, however T7 treatment in the second season also gave the higher average fruit weight. In this respect, the control (T1) and T6 treatments were recorded the lowest value in the first season, and T1,T10,T6 and T8 treatments were recorded the lowest value in the second season.

Seed weight:

Results tabulated in Tables (3 and 4) indicted that the average seed weight significantly increased by most treatments. The T4,T7,T2,T9,T1,T10 and T5 treatments gave the highest average seed weight in the beser stage during the first season, while in the second season seed weight did no significant different between all treatments.

Fruit flesh weight:

Data in Tables (3&4) clearly indicated that T4 treatment gave the highest significantly fruit flesh weight in the beser stage (11.71and 16.29 gm), during two seasons of the study, respectively, however control (T1)gave the lowest fruit flesh weight in the first season. In this respect, the control (T1),T10, T6 and T8 treatments were recorded the lowest values.

Fruit size:

Data presented in Tables (3&4) clearly indicated that fruit size of "Khalas" cultivar was significantly

affected by different fertilization treatments. It was clearly noticed that T4 treatment gave the highest fruit size in the first season, while T4 and T7 treatments gave the highest fruit size in the second season. On the other hand, control (T1) and T6 treatments had the lowest fruit size in the first season, and T1,T10, T6 and T8 treatments produced the lowest fruit size in the second season.

Fruit length:

Data in Tables (3 and 4) indicated that fruit length was significantly affected by the different treatments for Khalas cultivar in the two seasons of study. In this respect, the best results were obtained from T4 and T7 treatments in the first season, while in the second season T5, T4, T7 and T2 treatments gave the longest fruits. On the other hand, T9 treatment gave the shortest fruits in the first season, as well as T1, T6, T9 and T10 treatments during the second season.

Fruit diameter:

It is obvious from Tables (3 and 4) that, T4,T6,T7,T3,T8,T10 and T2 treatments significantly produced the highest fruit diameter, In this respect, T1,T5 and T9 treatments produced the lowest fruit diameter in the first season, however in the second season fruit diameter did not affected by any treatments.

Table 2: Effect of levels potassium and phosphorus fertilization and application time on fruit set and yield of "Khalas" date palm cultivar during2010 and 2011 seasons

Treatments	Fruit set (%)		Bunch Weight (Kg)		Yield (Kg /palm)	
	2010	2011	2010	2011	2010	2011
T1=P0K0	47.15_{d}	42.45_{g}	8.00_{f}	7.67_{e}	80.00_{f}	76.67_{e}
T2=P1K2D1	69.96_{a}	66.53_{b}	8.78_{e}	8.89_{d}	87.77_{e}	88.90_{d}
T3=P1K2D2	64.50_{b}	66.03_{b}	12.22_{b}	12.78_{b}	122.23_{b}	127.80_{b}
T4=P1K2D3	57.26_{c}	62.09_{c}	14.40_{a}	14.34_{a}	144.00_{a}	143.37_{a}
T5=P1K1D1	65.04_{b}	60.27_{cd}	11.22_{c}	10.89_{c}	112.23_{c}	108.87_{c}
T6=P1K1D2	56.69_{c}	57.60_{d}	11.33_{c}	11.11_{c}	113.33_{c}	111.10_{c}
T7=P1K1D3	55.14_{c}	54.30_{e}	10.33_{d}	9.79_{d}	103.33_{d}	97.77_{d}
T8=P2K2D2	70.09_{a}	65.45_{b}	10.13_{d}	9.55_{d}	101.33_{d}	95.53_{d}
T9=P2K2D1	64.97_{b}	49.27_{f}	9.73_{d}	11.00_{c}	97.33_{d}	110.00_{c}
T10=P2K2D3	72.92_{a}	73.60_{a}	10.37_{d}	9.55_{d}	103.67_{d}	95.53_{d}
LSD 0.05 %	3.91	3.01	0.66	*0.99*	6.58	9.87

Means within each column with the same letter are not significant at 5% level.

Table 3: Effect of levels potassium and phosphorus fertilization and application time on fruit physical properties (Beser stage) of " Khalas" date palm cultivar during 2010 season.

Treatments	Fruit weight (g)	Seed weight (g)	Flesh weight (g)	Fruit volume (cm^3)	Fruit length (cm)	Fruit diameter (cm)
T1=P0K0	9.19_{g}	1.08_{abc}	8.11_{h}	9.33_{de}	3.34_{f}	2.27_{c}
T2=P1K2D1	11.25_{c}	1.10_{abc}	10.15_{c}	11.17_{b}	3.53_{cd}	2.38_{ab}
T3=P1K2D2	10.35_{de}	1.02_{c}	9.33_{de}	10.00_{c}	3.52_{cd}	2.42_{a}
T4=P1K2D3	12.88_{a}	1.17_{a}	11.71_{a}	13.17_{a}	3.73_{a}	2.43_{a}
T5=P1K1D1	10.26_{ef}	1.05_{abc}	9.21_{e}	10.33_{c}	3.40_{ef}	2.32_{bc}
T6=P1K1D2	9.37_{g}	1.04_{bc}	8.33_{g}	9.17_{e}	3.46_{de}	2.43_{a}
T7=P1K1D3	11.75_{b}	1.15_{ab}	10.60_{b}	11.50_{b}	3.67_{ab}	2.43_{a}
T8=P2K2D2	10.25_{ef}	1.04_{bc}	9.21_{e}	10.00_{c}	3.52_{cd}	2.42_{a}
T9=P2K2D1	10.03_{f}	1.10_{abc}	8.93_{f}	9.83_{cd}	3.17_{g}	2.25_{c}
T10=P2K2D3	10.52_{d}	1.06_{abc}	9.46_{d}	10.33_{c}	3.62_{bc}	2.40_{a}
LSD 0.05 %	0.24	0.12	0.20	0.53	0.11	0.07

Means within each column with the same letter are not significant at 5% level.

Table 4: Effect of levels potassium and phosphorus fertilization and application time on fruit physical properties (Beser stage) of " Khalas" date palm cultivar during 2011 season.

Treatments	Fruit weight (g)	Seed weight (g)	Flesh weight (g)	Fruitvolume (cm^3)	Fruit length (cm)	Fruit diameter (cm)
T1=P0K0	14.08e	1.22	12.86f	13.50g	3.70e	2.57a
T2=P1K2D1	15.49b	1.09	14.40c	15.17cd	3.93abc	2.67a
T3=P1K2D2	14.80cd	1.14	13.66de	14.33ef	3.87bcd	2.57a
T4=P1K2D3	17.49a	1.20	16.29a	16.83a	3.97ab	2.67a
T5=P1K1D1	15.33bc	1.17	14.16cd	15.53bc	4.03a	2.67a
T6=P1K1D2	14.43de	1.08	13.35ef	13.83fg	3.83bcde	2.57a
T7=P1K1D3	16.89a	1.23	15.66b	16.17ab	3.97ab	2.67a
T8=P2K2D2	14.60de	1.15	13.45ef	14.00efg	3.87bcd	2.67a
T9=P2K2D1	15.30bc	1.14	14.16cd	14.67de	3.80cde	2.63a
T10=P2K2D3	14.18e	1.10	13.08ef	13.50g	3.77de	2.57a
LSD 0.05 %	0.62	N.S	0.60	0.68	0.15	0.13

Means within each column with the same letter are not significant at 5% level.

These increment in fruit physical characteristics may be due to the potassium application, where it plays an important role in, pH stabilization, osmoregulation, enzyme activation, protein synthesis, stomatal movement, photosynthesis, and cell extension (Läuchli and Pfluger, 1978). Moreover, potassium is an important solute in expanding cells (Marchner, 1986). These results are in agreement with those obtained by Sinclair *et al.* (1981), Bacha and Abo-Hassan (1982), EI-Hammady *et al.* (1991), Bamiftah (2000), Soliman and Osman (2003), Fahim and Saleh (2007) and Osman (2010) studied the effect of potassium fertilization on yield, fruit quality of date palm, and found that potassium applied gave the highest fruit and flesh weight and length.

Fruit Chemical characteristics:

Total soluble solids percentage (TSS %):

Data presented in Tables (5 and 6) showed that T4 and T7 treatments caused a slight increased total soluble solids in fruit at Tamer stage in the first season, while in the second season, T4, T7,T2 and T5 treatments gave the highest TSS %. On the other hand, the lowest contents of total soluble solids in juice were in the control (T1) during two seasons of the study.

Total acidity percentage:

Results in Tables (5 and 6) indicated that total fruit acidity percentage were did not significantly affected by different treatments.

Sugars content:

Data presented in Tables (5 and 6) indicated that the reducing sugars was significantly affected by different treatments. Reducing sugar percentage in the Tamer fruit stage were highly from trees treated by T5,T4,T7 and T3 treatments, but T1,T6,T9 and T10 treatments gave the lowest values in the first season. Moreover, in the second season,T2, T5, T6, T7, T8, T9 and T10 treatments gave the highest fruit content of reducing sugars, while T1 and T3 treatments reduced the reducing sugar content.

Regarding the non-reducing sugars, the data in Tables (5 and 6) indicated that the fruit non-reducing sugars content were affected significantly by different treatments. T4 treatment gave the highest values during two seasons of the study, on the other hand T5 treatment produced the least value in the first season, and T10 gave the lowest contents of non-reducing sugars in the second season.

As for the total sugars content, results in Tables (5&6) showed that fruit total sugars content was significantly affected by the different treatments. Trees treated by T4 treatment increased total sugars in fruits in Tamer stage, on the other hand trees treated by T1 treatments gave the lowest value during this study.

Moisture content percentage:

Moisture content percentage of Khalas fruits were did not affected by different treatments in tamer stages (Table 5&6).

These results are due to the fact that potassium activates the enzymes involving in sugar biosynthesis and helps in translocation of sugars (Evans and Sorger, 1966 and Archer, 1985). In addition, Suelter (1970) mentioned that there are more than 50 enzymes which are stimulated by potassium. The obtained results appeared to be in close agreement with the findings reported by EI-Hammady *et al.* (1991), Bacha and Abo-Hassan (1982), Bamiftah (2000), Soliman and Osman (2003), Osman (2009) and Osman (2010) they found that chemical fertilizers (NPK) improved chemical (TSS%, total, reducing and non-reducing sugars percentage) properties.

Table 5: Effect of levels potassium and phosphorus fertilization and application time on fruit chemicalproperties (Tamer stage) of " Khalas" date palm cultivar during 2010 season.

Treatments	Total soluble solids (%)	Total acidity (%)	Reducing sugars (%)	Non- Reducing sugars (%)	Total sugars (%)	Moisture content (%)
T1=P0K0	66.00_{h}	0. 51	36.83_{c}	17.82_{abc}	54.65_{e}	18.44
T2=P1K2D1	74.00_{bc}	0. 53	46.73_{b}	15.91_{c}	62.64_{bc}	15.50
T3=P1K2D2	71.10_{ef}	0. 44	47.74_{ab}	13.41_{d}	61.15_{c}	15.75
T4=P1K2D3	76.00_{a}	0. 46	47.91_{ab}	20.04_{a}	67.95_{a}	15.25
T5=P1K1D1	72.80_{cd}	0. 60	50.44_{a}	8.68_{e}	59.12_{d}	17.47
T6=P1K1D2	69.60_{f}	0. 48	38.67_{c}	18.75_{a}	57.42_{d}	18.19
T7=P1K1D3	75.20_{ab}	0. 50	47.91_{ab}	16.37_{bc}	64.28_{b}	15.70
T8=P2K2D2	70.00_{f}	0. 48	46.27_{b}	11.15_{d}	57.42_{d}	16.64
T9=P2K2D1	72.00_{de}	0. 53	38.69_{c}	18.73_{a}	57.42_{d}	17.83
T10=P2K2D3	68.00_{g}	0. 51	39.48_{c}	18.45_{ab}	57.93_{d}	16.78
LSD 0.05 %	1.51	N.S	2.80	2.30	1.91	N.S

Means within each column with the same letter are not significant at 5% level.

Table 6: Effect of levels potassium and phosphorus fertilization and application time on fruit chemical properties (Tamer stage) of "Khalas" date palm cultivar during 2011 season

Treatments	Total soluble solids (%)	Total acidity (%)	Reducing sugars (%)	Non- Reducing sugars (%)	Total sugars (%)	Moisture content (%)
T1=P0K0	73.00_{d}	0.33	33.27_{d}	13.30_{bcd}	46.57_{e}	17.43
T2=P1K2D1	78.00_{abc}	0.57	40.67_{a}	13.51_{bcd}	54.18_{abc}	17.10
T3=P1K2D2	77.20_{bc}	0.57	33.63_{cd}	18.47_{ab}	52.10_{abcd}	19.77
T4=P1K2D3	79.60_{a}	0.63	34.93_{bcd}	22.27_{a}	57.20_{a}	16.67
T5=P1K1D1	77.60_{abc}	0.63	36.67_{abcd}	16.57_{abc}	53.24_{abcd}	18.93
T6=P1K1D2	76.80_{c}	0.33	37.63_{abcd}	11.67_{cd}	49.30_{cde}	18.00
T7=P1K1D3	79.20_{ab}	0.37	37.57_{abcd}	17.90_{ab}	55.47_{ab}	18.57
T8=P2K2D2	76.80_{c}	0.30	37.73_{abcd}	13.03_{bcd}	50.76_{bcde}	18.23
T9=P2K2D1	77.20_{bc}	0.33	38.97_{ab}	13.43_{bcd}	52.40_{abcd}	17.90
T10=P2K2D3	76.00_{c}	0.33	38.03_{abc}	10.07_{d}	48.10_{de}	19.07
LSD 0.05 %	2.02	N.S	4.63	5.94	5.18	N.S

Means within each column with the same letter are not significant at 5% level.

Leaf mineral contents:

Data presented in Tables (7&8) showed that a significant effect of potassium and Phosphorus fertilization on levels pinnae elemental contents (i.e. N, P, K, Fe, Zn and Mn).

Pinnae nitrogen percent:

The results showed that, pinnae nitrogen content was significantly affected by different level of potassium and phosphorus fertilization treatments. T2 treatment (high level K applied in one doses) increased significantly pinnae nitrogen content in the first season, while in the second season,T2,T4,T5 and T7 treatments. On the other hand control treatment (T1) gave the lowest value during this study.

Pinnae phosphorus percent:

The pinnae phosphorus concentration was significantly increased with treated Khalas date palm trees by T3,

T8 and T10 treatments (high level potassium) in the first season, however in the second season, T10 treatment gave the highest value. However control(T1)gave the lowest phosphorus content in pinnae during the two seasons of study.

Pinnae potassium percent:

The pinnae potassium concentration in Khalas date palm significantly increased with increasing the level and doses of potassium fertilization (Tables7 and 8). Treatments, T3 and T4 (2.0 kg per palm) applied in two or three doses gave the highest potassium concentration than those of other fertilization treatments and control, which gave the lowest values.

Pinnae iron content:

Pinnae iron concentration of Khalas date palm, the data in Tables (7&8) showed that a significantly Fe increased by trees treated by T7 treatment, while T1 treatment gave the lowest iron concentration values during this study.

Pinnae Zinc and manganese content:

It is noticed from the obtained results in Tables (7 and 8) showed that all treatments of this study decreased Zn and Mn Pinnae contents of Khalas date palm, on the other hand control (T1) gave the highest values during two seasons of the study. These results are supported by those reported by El- Hammady *et al*., (1991), Kassem *et al*. (1997), Soliman and Osman (2003), Shahin (2007), Osman (2009) and Osman (2010)they found that the leaf N, P and K content increased, while Zn decreased with increasing the N and K rates Fertilization.

Table 7: Effect of levels potassium and phosphorus fertilization and application time on leaf mineral content of Khalas date palm cultivar during 2010 season

Treatments	N %	P %	K %	Fe Ppm	Zn ppm	Mn ppm
T1=P0K0	1.07 d	0.10 b	1.23 g	164.3 cde	19.40 a	16.63 a
T2=P1K2D1	1.50 a	0.17 ab	1.50 cd	144.8 e	18.27 ab	14.30 c
T3=P1K2D2	1.40 b	0.20 a	1.63 a	201.0 bc	18.43 ab	11.13 e
T4=P1K2D3	1.23 c	0.17 ab	1.60 ab	152.1 de	18.10 abc	15.60 b
T5=P1K1D1	1.37 b	0.13 ab	1.40ef	191.2 bcd	17.13 bcd	12.23 d
T6=P1K1D2	1.37 b	0.17 ab	1.37 f	169.2 cde	17.53 bcd	10.77 e
T7=P1K1D3	1.37 b	0.17 ab	1.53 bc	328.1 a	16.43 cde	15.37 b
T8=P2K2D2	1.40 b	0.20 a	1.43 def	229.7 b	17.97 abcd	15.40 b
T9=P2K2D1	1.40 b	0.13 ab	1.40 ef	224.4 b	15.23 e	13.63 c
T10=P2K2D3	1.37 b	0.20 a	1.47 cde	226.2 b	16.33 de	15.53 b
LSD 0.05 %	0.10	0.08	0.08	46.1	1.69	0.93

Means within each column with the same letter are not significant at 5% level.

Table 8: Effect of levels potassium and phosphorus fertilization and application time on leaf mineral content of Khalas date palm cultivar during 2011 season

Treatments	N %	P %	K %	Fe Ppm	Zn ppm	Mn ppm
T1=P0K0	1.64_{d}	0.16_{e}	1.32_{d}	175.7_{d}	70.77_{a}	21.87_{a}
T2=P1K2D1	2.59_{a}	0.18_{de}	1.51_{b}	194.5_{cd}	65.73_{b}	18.57_{e}
T3=P1K2D2	2.10_{b}	0.27_{b}	1.59_{a}	242.2_{b}	64.33_{b}	15.90_{g}
T4=P1K2D3	2.58_{a}	0.23_{c}	1.60_{a}	193.5_{cd}	62.20_{b}	20.49_{bc}
T5=P1K1D1	2.46_{a}	0.19_{d}	1.50_{b}	241.6_{b}	55.23_{c}	17.17_{f}
T6=P1K1D2	2.12_{b}	0.25_{bc}	1.42_{c}	191.2_{cd}	49.37_{de}	16.10_{fg}
T7=P1K1D3	2.57_{a}	0.20_{d}	1.53_{b}	308.3_{a}	51.83_{cd}	20.53_{bc}
T8=P2K2D2	2.15_{b}	0.27_{b}	1.43_{c}	204.4_{c}	47.03_{e}	20.50_{bc}
T9=P2K2D1	2.18_{b}	0.28_{ab}	1.44_{c}	226.9_{b}	45.37_{ef}	19.20_{de}
T10=P2K2D3	1.82_{c}	0.30_{a}	1.40_{c}	237.9_{b}	42.5_{f}	20.30_{cd}
LSD 0.05 %	0.17	0.03	0.05	21.49	4.30	1.14

Means within each column with the same letter are not significant at 5% level.

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