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Yield and chemical composition of 'Piarom' Date-Palm *Phoenix dactylifera* as affected by nitrogen and phosphorus levels

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Abstract

Extraordinary importance of Date-Palm, *Phoenix dactylifera* especially 'Piarom' variety and also undeniable effect of nitrogen and phosphorus on yield and quality of this product, caused this research to be accomplished. The research was performed during two years on 72 (4*3*3*2=72 trees) fruitful, 12 years old trees in Hormozgan province. Treatments were consisted of four levels of nitrogen (0, 350, 700 and 1050 grams tree^{-1}) and three levels of phosphorous (0, 300 and 600 grams tree^{-1}) with three replications. Sources of nitrogen and phosphorus were urea and triple super phosphate (TSP), respectively. This experiment was accomplished in a factorial manner and in a randomized complete blocks design. Fruit thinning was done in a ratio of eight leaves to one cluster. Irrigation was done through drip system and pollination according to the custom of the region. After harvesting, some plant parameters such as production yield, concentration of essential elements in leaves, average of fruit weight, reducing sugar percentage in fruits, fruit Brix and the weight ratio of fruit pulp to it's stone were determined. Results showed that nitrogen levels caused significant variations in many considered parameters but not in concentration of copper, zinc and manganese in leaves. The effect of phosphorus levels on all plant responses was meaningful except for concentration of nitrogen, zinc, copper and manganese in leaves. Furthermore, interaction of nitrogen and phosphorus was meaningful in some cases.

***Keywords**:* Fruit quality; Nitrogen; Phosphorus; Piarom; Yield

Introduction

According to climatic condition of northern parts of Hormozgan province, there is a large potential for producing Date-Palm, specially 'Piarom' variety in this area. This production has a good market in the world and so, could bring considerable income to the native farmers. Now, palm-groves of mentioned regions are managed traditionally. In this type of management, proper plant nutrition and soil fertility protection are not completely considered. Determination of optimum levels of fertilizers for this plant, causes more yield production, higher quality of fruits and considerable reduction in the farm expenses. Present study was done in order to study the effects of nitrogen and phosphorus application on yield and chemical composition of 'Piarom' Date-Palm in Hormozgan province. Longitude and latitude of experimental site were 28° 18′ N and 55° 54′ E, respectively.

Karami (2007) observed that application of 800 grams nitrogen and 375 grams phosphorus for each tree caused the highest yield production (14049 kg ha^{-1}) in Date-Palm, variety `Mordaseng` in Minab. In Jahrom, 800 g N and 650 g P_2O_5 per tree was the best (Shahrokhnia, 1992). Other research in Bam area (Sabbah, 1993) showed that using 750 g N and 750 g P_2O_5 for each fruitful tree, caused the highest yield production. Bliss and Mathez (1983) studied the fertilizer necessity of Date-Palm variety `Arkel` in California. They found the best fertilizer recommendation as 930 g N and 620 g P_2O_5 for each tree in each year. Sinclair *et al.* (1981) also investigated the effects of different fertilization levels on growth and chemical composition of Date-Palm. They believed that using 1100 g N and 800 g P_2O_5 for each fruitful tree caused the best yield and fruit quality. Bilsborough and Blackpool (2000) in the international symposium of Date-Palm in Namibia, explained the apparent symptoms of nutrients deficiency in young Date-Palm. Saleh (2008) showed that using 2.5 kg NPK (named as complete macrofertilizer) along with micronutrient fertilizers caused the highest yield and best fruit quality. Trees with smaller biomass need fewer fertilizers. For instance, Rajaie et al. (2009) suggested the combination of 50 μg nitrogen and 20 μg phosphorous g $soil^{-1}$ (beside other essential nutrients) for one-year old lemon seedlings in a greenhouse experiment.

Regarding the desirable effects of macronutrients application on yield and fruit quality and this fact that in most palm-groves in this province, fertilizers are not applied in proper values, it is necessary to determine the optimum levels and ratios of chemical fertilizers in order to increase yield and improve fruit quality. Therefore, main aim of this study is determination of optimum levels and ratios of nitrogen and phosphorus fertilizers in order to obtain maximum yield and desirable fruit quality in Date-Palm, variety `Piarom`.

Materials and Methods

The experiment was conducted during two years and on 72 fruitful, 12 years old trees in Hormozgan province. Treatments were consisted of four levels of nitrogen (0, 350, 700 and 1050 grams $tree^{-1}$) and three levels of phosphorous (0, 300 and 600 grams $tree^{-1}$) as localized placement method -named Chalkood- with three replications. Two trees were considered in each replication. Sources of nitrogen and phosphorus were urea and triple super phosphate (TSP), respectively. One second of nitrogen and all of phosphorus was used in February. Rest of nitrogen was applied in May, each year. This research was accomplished in a factorial manner and in a randomized complete blocks design. Fruit thinning was done in a ratio of eight leaves to one cluster. Irrigation was done through drip system and pollination according to the custom of the region. After harvesting, production yield, concentration of N, P, K, Fe, Cu, Zn and Mn in young leaves, fruit average weight, fruit reducing sugar percentage, fruit Brix and the weight ratio of fruit pulp to it's stone were determined. Obtained data were analyzed statistically. Means comparison was done through Duncan's multiple range test using MSTATC software. Tables 1 and 2 show the results related to soil and water analysis before starting the experiment.

Table1. Soil sample analysis of experimental site.

Soil depth (cm)	EC (ds m^{-1})	O.C (%)	Clay (%)	Available P	Available K	Fe	Mn	Zn	Cu	B
				(mg kg^{-1})						
0-30	2.71	0.59	19	10.32	127	10.70	2.73	0.83	0.79	1.29
30-60	1.89	0.45	14	9.14	104	8.65	1.51	0.49	0.73	0.96

Table 2. Water sample analysis for experimental site.

EC (µmhos cm^{-1})	pH	CO_3	HCO_3	Cl	Na	B	Ca	Mg
		(meq L^{-1})						
2350	7.93	0.4	4.6	6.7	6.9	1.9	3.1	2.4

Results

Some plant parameters such as concentration of zinc, copper, manganese and nitrogen in young leaves were not affected by treatments. Therefore, the results related to mentioned parameters were omitted.

According to table 3, production yield of `Piarom` Date-Palm increased with nitrogen application. Using 1050 g N $tree^{-1}$ caused the highest yield, that is, 166.94 kg $tree^{-1}$. Phosphorus application also significantly enhanced the yield in a way that using 600 g phosphorus $tree^{-1}$, increased the yield from 89.84 kg $tree^{-1}$in control to 94.4/ kg $tree^{-1}$. Furthermore, interactive effects of N and P caused meaningful increase in yield.

Table 3. Effect of N and P levels on yield and nitrogen content.

Nitrogen level (g $tree^{-1}$)	Phosphorus level (g $tree^{-1}$) 0	300	600	Mean
	Yield (Kg $tree^{-1}$)			
0	89.84 d*	90.78 d	94.40 c	91.67 d
350	94.57 c	95.58 c	96.92 c	95.69 c
700	99.82 b	103.98 b	104.65 b	102.82 b
1050	106.94 a	109.50 a	114.03 a	110.16 a
Mean	97.79 C	99.96 B	102.50 A	
	Nitrogen content of young leaves (mg kg^{-1} dry wt.)			
0	1551 c	1568 c	1572 d	1564 d
350	1640 b	1719 b	1690 c	1683 c
700	1840 a	1873 a	1808 b	1840 b
1050	1893 a	1935 a	1897 a	1908 a
Mean	1731 B	1774 A	1742 AB	

*:Values followed by the same small letter in each column or capital letter in each row, are not significantly different at P≤0.05.

All nitrogen levels caused significant increase in nitrogen content of young leaves. The most increase rate in leaves nitrogen concentration was 22% that resulted from 1050 g N $tree^{-1}$, in comparison with control. However, phosphorus treated trees showed no significant differences in nitrogen content. Also, there was no interaction between nitrogen and phosphorus levels (Table 3).

Using 1050 g N $tree^{-1}$ raised phosphorus concentration in leaves, although, treatments 350 and 700 g N $tree^{-1}$ had no statistical difference with control (Table 4). Application of

300 and 600 g phosphorus tree^{-1} also caused an increase in phosphorus concentration of Date-Palm leaves. Interaction effects between nitrogen and phosphorus was in a way that in all phosphorus levels, 1050 g nitrogen tree^{-1} increased phosphorus concentration in young leaves.

Fertilization with nitrogen created significant changes in the potassium concentration of Date leaves. For instance, application of 1050 g N tree^{-1} increased leaf's potassium content from 4923 mg kg^{-1} dry weight in control to 5288. It was the highest rate of potassium in leaves. Furthermore, there is no considerable difference between control, 350 and 700 g N tree^{-1} (Table 4). Table 4, also shows that potassium content of leaves was affected by phosphorus levels in a way that levels 300 and 600 g phosphorus tree^{-1} caused statistical increase in potassium concentration. In the level 600 g phosphorus tree^{-1}, nitrogen application caused no change in nitrogen content of leaves. Whereas, in other P levels, significant increase in leaf's K content was seen with using 1050 g N tree^{-1}.

Investigation of table 5, shows that using 700 g N tree-^{1} increased Fe concentration of leaves, in comparison with control. Levels 700 and 1050 were statistically similar. On the other hand, using phosphorus wasn't able to increase Fe content in leaves. Interaction between N and P levels was meaningful but just using 350 g N tree^{-1} caused statistical difference with control. Levels 700 and 1050 of nitrogen showed the same effect on leaf Fe content.

Nitrogen had significant effect on the average weight of a fruit at 5% level. 1050 g N tree^{-1} caused an increase in the weight of a fruit, that is, 8.27 in comparison with control, that is, 7.83 gram. Phosphorus levels decreased the average weight of a fruit. Interactive effects of N and P, were also meaningful in a way that nitrogen application, showed considerable increase in fruit weight (Table 5).

Table 4. Effect of N and P levels on phosphorus and potassium content.

Nitrogen level (g tree^{-1})	Phosphorus level (g tree^{-1})			
	0	300	600	Mean
	Phosphorus content of young leaves (mg kg^{-1} dry wt.)			
0	2092 b*	2227 b	2282 b	2200 b
350	2140 ab	2199 b	2304 b	2214 b
700	2120 ab	2229 b	2418 a	2256 b
1050	2217 a	2407 a	2371 ab	2331 a
Mean	2142 C	2265 B	2344 A	
	Potassium content of young leaves (mg kg^{-1} dry wt.)			
0	4923 c	5103 b	5127 a	5051 b
350	4962 bc	5171 b	5142 a	5091 b
700	5060 b	4968 c	5224 a	5084 b
1050	5288 a	5297 a	5233 a	5273 a
Mean	5058 B	5135 A	5182 A	

*: Values followed by the same small letter in each column or capital letter in each row, are not significantly different at P≤0.05.

According to table 6, nitrogen was able to change the amounts of soluble solids (Brix) in fruit, however, the trend wasn't absolutely regular. In general, it can be concluded that with increase in nitrogen application, fruit Brix increased in a way that the level 700 g nitrogen for each tree, was the best. Table 6, shows that phosphorus application changed the Brix index. The treatment 600 g P tree^{-1}, reduced the fruit Brix, significantly. Brix was also affected by interaction of N and P levels, however, no certain trend was observed.

Table 5. Effect of N and P levels on leaves Fe content and weight of a fruit.

Nitrogen level (g tree^{-1})	Phosphorus level (g tree^{-1})			
	0	300	600	Mean
	Fe content of young leaves (mg kg^{-1} dry wt.)			
0	159.7 b*	165.5 b	158.2 b	161.1 c
350	171.3 b	179.1 a	198.0 a	182.8 b
700	188.9 a	182.4 a	197.0 a	189.4 a
1050	183.4 a	186.0 a	201.3 a	190.2 a
Mean	175.8 B	178.3 B	188.6 A	
	Average weight of a fruit (g)			
0	7.83 b	7.35 b	7.05 d	7.41 b
350	6.92 c	7.14 c	7.27 c	7.11 c
700	6.91 c	7.38 b	7.82 b	7.37 b
1050	8.27 a	7.89 a	8.73 a	8.30 a
Mean	7.49 B	7.44 B	7.72 A	

*:Values followed by the same small letter in each column or capital letter in each row, are not significantly different at P≤0.05.

The weight ratio of fruit pulp to its stone was affected by N levels. Using 700 g N tree^{-1} caused no change in comparison with control, but the next level, that is, 1050, increased this proportion statistically. Application of phosphorus didn't affect this ratio but in treatment 700 g N tree^{-1}. In this level, use of 300 g P tree^{-1} was as effective as control, where application of 600 g P tree^{-1} raised the ratio more than 20%. Interactive effects of N and P showed meaningful change in all levels. In each P level, nitrogen fertilization caused significant increase in the ratio of fruit pulp to its stone, in an order that the highest ratio resulted from 1050 g N tree^{-1} (Table 6).

Table 6. Effect of N and P levels on Brix index and the weight ratio of fruit pulp to stone.

Nitrogen level (g tree^{-1})	Phosphorus level (g tree^{-1})			
	0	300	600	Mean
	Brix of fruit			
0	67.07 b*	66.19 c	64.47 c	65.91 b
350	64.56 c	65.44 d	62.38 d	64.13 c
700	68.32 a	68.65 a	67.33 b	68.10 a
1050	66.87 b	67.05 b	69.27 a	67.73 a
Mean	66.71 A	66.83 A	65.86 B	
	Weight ratio of fruit pulp to stone			
0	7.07 b	6.61 c	7.03 b	6.90 c
350	6.62 c	6.97 bc	6.87 b	6.82 c
700	6.84 bc	7.24 b	8.22 a	7.43 b
1050	8.24 a	8.11 a	8.53 a	8.30 a
Mean	7.19 B	7.23 B	7.66 A	

*:Values followed by the same small letter in each column or capital letter in each row, are not significantly different at P≤0.05.

Increase in both nitrogen and phosphorus levels enhanced the amount of reducing sugars in Date fruits. The least and the most amounts of reducing sugars in fruit (69.44% and 79.03%) were observed in control and 1050 g N tree^{-1} treatment, respectively. Application of 600 g phosphorus for each tree also caused an increase over 4% in reducing sugars content in fruit, in comparison with control. Furthermore, interaction between N and P was significant and in each phosphorus level, reducing sugar percentage of fruit, increased with nitrogen fertilization. The highest rate of reducing sugar percentage in fruit was seen in treatment 1050 g N tree^{-1} (Table 7).

Table 7. Effect of N and P levels on reducing sugars of fruit.

Nitrogen level (g tree^{-1})	Phosphorus level (g tree^{-1})			
	0	300	600	Mean
0	69.44 d*	71.12 d	72.40 c	70.99 d
350	73.80 c	74.39 c	76.43 b	74.87 c
700	74.74 b	75.79 b	78.08 a	76.20 b
1050	79.03 a	77.97 a	78.40 a	78.47 a
Mean	74.25 C	74.82 B	76.33 A	

*: Values followed by the same small letter in each column or capital letter in each row, are not significantly different at P≤0.05.

Discussion

Application of 1050 g nitrogen and also using 600 g phosphorus for each tree, caused the highest yield. Furthermore, interactive effects of these two treatments showed more increase in yield. Nitrogen is necessary for protein synthesis and energy carriers like ATP (adenosine tri phosphate) need phosphorus (Mengael and Kirkby, 1978), so, using these essential elements could increase the yield. Yield increase with using nitrogen and phosphorus fertilizers in Date-Palm was also reported by Karami (2007) in Minab, Sabbah (1993) in Jiroft and Bliss and Mathez (1983) in California.

Leaf nitrogen content increased with increasing nitrogen levels. But phosphorus didn't create any significant change in leaf nitrogen in different treatments. But interaction of N and P showed a considerable increase. In general, the highest level of nitrogen caused the most increase in nitrogen concentration in leaves. It is obvious that addition of nitrogen to soil in a prepared condition for element absorption and transportation causes the increase in element concentration in plant. Similar results were observed in the United States (Fur *et al.*, 1951; Nixon and carpenter, 1978).

Application of 1050 g N tree^{-1} enhanced phosphorus content of leaves in comparison with other nitrogen levels. Phosphorus fertilization also raised leaf's P concentration with a statistical similarity between 300 and 600 g tree^{-1} levels. On the other hand, interactive effects of N and P were in a way that the best P level is 600 g tree^{-1}. Adequate nitrogen results plant growth stimulation and increase in nutrient uptake from rhizosphere (Mengael and Kirkby, 1978). Increase in phosphorus leaf content, due to the nitrogen fertilization was reported by fur *et al.* (Fur et al., 1951) in Date-Palm variety Deglat Nour.

Results showed that potassium leaf concentration increased in treatments 700 and 1050 g N tree^{-1}. Application of 300 and 600 g phosphorus for each tree also caused increase of potassium leaf content. Other researchers (Sabbah, 1993; Bliss and Mathez, 1983; Sinclair et al., 1981) reported that nitrogen increased the concentration of potassium in leaves. In general, it can be concluded that use of 1050 g N plus 300 g P for each tree showed the best result.

Treatments 700 and 1050 g N tree^{-1} similarly increased the leaf Fe content in Date-Palm, whereas phosphorus wasn't able to change Fe concentration in leaves. On the other hand, interaction effects resulted the highest rate in 700 g nitrogen and 600 g phosphorus for each tree. Therefore, the best fertilizer recommendation in order to increase leaf Fe content is 700 g N in addition to 600 g P tree^{-1}. Availability of Nitrogen can cause increase in reducing power of root surface and finally, iron uptake from root surface. Consecutively, it can be transported in plant more easily (Broschat, 1999; Mengael and Kirkby, 1978).

Application of 1050 g nitrogen and 600 g phosphorus created the most increase in average weight of a fruit, either separately or in combination. Nitrogen and phosphorus are necessary for photosynthesis and synthesis of sugar products. These products will increase size and weight of fruits (Carpenter, 1981; Dawson and Pansiot, 1965). Positive effects of nitrogen and potassium fertilizers on weight of a fruit in Date-Palm has been reported by others (Shahrokhnia, 1992; Shahrokhnia, 1996; Bliss and Mathez, 1983).

The highest rate of Brix index was obtained with using 700 g nitrogen for each tree. But phosphorus caused reduction of this index in all levels. Interactive effects changed the result in a way that the best result was observed with combination of 1050 g N and 600 g P for each tree. Preparing adequate amounts of essential elements such as N and P will improve nutrient absorption and carbohydrate synthesis. Accumulation of these soluble solids in Date fruits, raise the Brix index (Sanadgol, 1991; Carpenter, 1981). Increasing soluble solids in Date fruits through nitrogen and phosphorus fertilization has been reported by other researchers (Abdul Baki et al., 1998; Bliss and Mathez, 1983; Fur et al., 1951; Sinclair et al., 1981).

The weight ratio of fruit pulp to its stone increased with nitrogen and phosphorus application in an order that the best combination was 700 g N plus 600 g P tree^{-1}. On the other hand, combination of 1050 g nitrogen and 600 phosphorus enhanced reducing sugars percentage in fruits. Optimum fertilization in plants, among them Date-Palm, improves quantitative and qualitative properties of production. Increase in reducing sugars content could be due to necessity of nitrogen and phosphorus for synthesis of sugar products and photosynthesis (Broschat, 199; Mengael and Kirkby, 1978; Sinclair et al., 1981). Other researchers (Bliss and Mathez, 1983; Sinclair et al., 1981) showed the desirable effects of N and P fertilization on increasing reducing sugars.

Regarding yield and fruit quality, application of 1050 g nitrogen caused the best results, in most cases. Also, using 600 g phosphorus for each tree increased yield and most qualitative parameters except for Brix and leaf nitrogen content. It is hard to say about the interactive effects of phosphorus and nitrogen levels. In some cases, using 300 g P plus 700 or 1050 g N tree^{-1} caused the best results and in other ones, application of 600 g P along with 1050 g N tree^{-1} or even control treatment, created the best observations. In general, it can be conclude that using 600 g P plus 700 g N tree^{-1} caused the most increase in leaf Fe content and weight ratio of fruit pulp to its stone. Other plant responses such as production yield, phosphorus and potassium concentration in leaves, average weight and Brix index of a fruit and fruit reducing sugar content were improved through application of 600 g P along with 1050 g N tree^{-1}. Nitrogen concentration of leaves increased with using 700 g N and 300 g P application together.

In general, it can be found that balanced application of nutrient elements, among them nitrogen and phosphorus is required for optimum nutrition of plants. Sometimes, overusing an essential element gives reverse results and shows reduction in yield and fruit quality. Therefore, nutrient requirements of Date-Palm must be determined through scientific research in each area and be exactly applied.

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