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Increasing yield and fruit quality of date palm 'Sayer' with application of nitrogen, phosphorus and potassium optimum levels

Abstract

Date palm, *Phoenix dactylifera*, is one of the most important horticultural crops in Khuzestan Province. Among the date palm cultivars in province date palm 'Sayer' is one of the most commercial cultivars. The low annually average of yield and fruit quality is as a problem for date growers. On the other hand, the most of date growers are not applying chemical fertilizers or applying them in improper amounts. Due to the important of date palm and so the important of minerals element especially nitrogen, phosphorus and potassium in increasing yield and fruit quality, determination of optimum levels of them for date palm fertilization is necessity. In order to increasing yield and fruit quality of 'Sayer' date palm, this experiment with twelve treatments and four replications was carried out in a randomized complete block design on 48 'Sayer' date

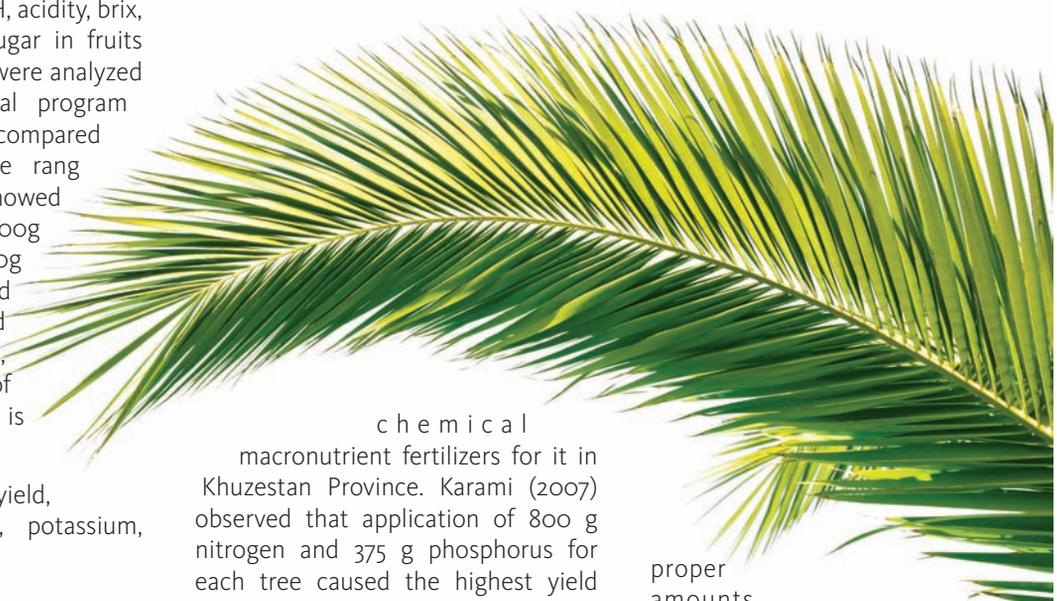
palm during four years in Khuzestan Province. Treatments were consisted of three levels of nitrogen ($N_1=700$, $N_2=1000$ and $N_3=1300$ grams tree⁻¹), two levels of phosphorus ($P_1=500$ and $P_2=650$ grams tree⁻¹) and two levels of potassium ($K_1=1000$ and $K_2=1300$ grams tree⁻¹). Source of nitrogen, phosphorus and potassium were urea, triple super phosphate (TSP) and potassium sulfate respectively. These treatments along with 20 kg of manure and chemical micronutrient fertilizers based on general recommendation applied for each tree in winter by localized placement method (Chalkood). The number of 20-25 leaflets from middle of leaf in second row was picked up, and mineral nutrients of them were determined, each year. At harvesting time, plant parameters such as yield, concentration of mineral elements in leaf, average of weight, length, diameter and volume of fruit fresh, weight of stone and Weight ratio of

fruit pulp to its stone, pH, acidity, brix, reducing sugar, total sugar in fruits were determined. Data were analyzed with MSTATC statistical program and means of data were compared with Duncan's Multiple rang test. The results showed that application of 700g N, 500g P₂O₅ and 1300g K₂O for each tree caused the highest yield and fruit quality. Therefore, annually application of them to date growers is recommended.

Key words: date palm, yield, fruit quality, nitrogen, potassium, phosphorus

Introduction

Khuzestan Province is considered as one of the important regions of date production in Iran. According to agriculture statistic book of Iran, mature date plantation area and production in Khuzestan province are 26000 hectares and 142,000 tons (2003-2004). Among the date palm cultivars in province, date palm 'Sayer' with more than 68 percent of date palm plantation area is one of the most commercial cultivars. Annually average of yield production for it, is reported approximately 60-70 kg for each tree. While there is a higher production potential for this cultivar in this region. Now, Palm-groves of this Province are managed traditionally. In this type of management, proper plant nutrition and soil fertility protection are not completely considered. Therefore determination of optimum levels of fertilizers for this cultivar causes more yield and higher quality of date fruit, so could bring considerable income to farmers and is necessary. This experiment was done in order to study the effects of nitrogen, phosphorus and potassium on yield and fruit quality of 'Sayer' Date palm and determination of optimum levels of



chemical

macronutrient fertilizers for it in Khuzestan Province. Karami (2007) observed that application of 800 g nitrogen and 375 g phosphorus for each tree caused the highest yield production in date palm cultivar <Mordaseng> in Minab. Shahrokhnia (1992) reported that application of 800 g N and 650 g P₂O₅ per tree was the best fertilizer recommendation for date palm in Jahrom.. Sinclair et al (1981) investigated the effect of different fertilization levels on growth and chemical composition of date palm. They reported that application of 1100 g N and 800 g P₂O₅ for each fruitful tree caused the highest yield and fruit quality. Harhash (2000) recommended 1.5 Kg potassium sulfate/palm/year in date palm. Bamiftah (2000) recommended 2 or 3 Kg of potassium sulfate /palm/year for high yield and fruit quality in date palm 'Zaghloul'. Saleh (2008) showed that using 2.5 kg NPK (named as complete macro fertilizer) along with micronutrient fertilizers caused the highest yield and fruit quality. Dialami (2009) reported that application of proper amounts of nitrogen, phosphorus and potassium caused the best results on yield and fruit quality of date palm in Khuzestan province. 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 amounts,

it is necessary to determine the optimum levels and ratios of chemical fertilizers in order to increasing yield and improve fruit quality. Therefore, main aim of this study is determination of optimum levels and ratios of nitrogen, phosphorus and potassium in order to increasing yield and improving fruit quality date palm in cultivar 'Sayer'.

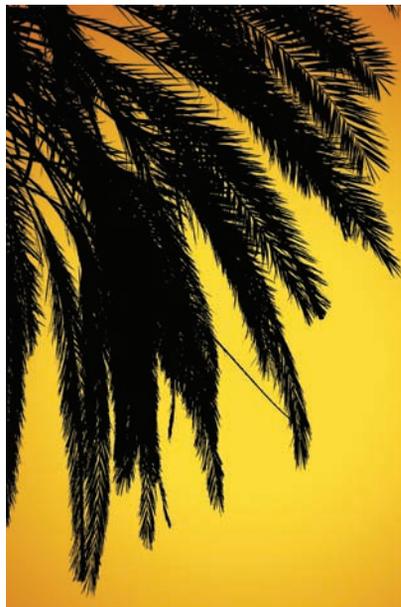
Materials and methods

This experiment was conducted during four years on 48 fruitful, 15 years old date palm in Khuzestan province. Before of application of treatments soil and water were sampled and analyzed (tables 1 and 2). Treatments were consisted of three levels of nitrogen (N₁=700, N₂=1000 and N₃=1300 grams tree⁻¹), two levels of phosphorus (P₁= 500 and P₂= 650 grams tree⁻¹) and two levels of potassium (K₁=1000 and K₂=1300 grams tree⁻¹). Treatments were: T₁=N₁P₁K₁, T₂=N₁P₁K₂, T₃=N₁P₂K₁, T₄= N₁P₂K₂, T₅=N₂P₁K₁, T₆=N₂P₁K₂, T₇=N₂P₂K₁, T₈=N₂P₂K₂, T₉=N₃P₁K₁, T₁₀=N₃P₁K₂, T₁₁=N₃P₂K₁, T₁₂=N₃P₂K₂. Source of nitrogen, phosphorus and potassium were urea,

triple super phosphate and potassium sulfate respectively. One second of nitrogen and all of phosphorus and potassium was used in February. Rest of nitrogen was applied in May, each year. These treatments along with 20 kg of manure and chemical micronutrient fertilizers based on general recommendation, consisted of application 150 g of zinc sulfate, iron sulfate, copper sulfate and manganese sulfate were applied for each tree in winter by localized placement method (Chalkood). Agro technical practices such as pollination, thinning, irrigation and so on, were done according to the custom of the region. Each year, in May, the number of 20-25 leaflets from middle of leaf in second row was picked up, and mineral nutrients of them were analyzed. At harvesting time, plant parameter such as yield, average of weight, length, diameter and volume of fresh fruit, weight of stone and Weight ratio of fruit pulp to its stone, pH, acidity, brix, reducing sugar, total sugar in fruits were determined. Data were analyzed with MSTATC statistical program and means of data were compared with Duncan's Multiple rang test.

Results and discussion

The presented data in table 3, 4 and 5 showed that some parameters of fruit quality such as concentration of nitrogen and phosphorus in leaf, diameter, pH, brix and acidity of fruit and stone weight were not affected by treatments. While, the effects of different fertilization treatments on the average yield/palm and fruit quality such as fresh weight, length and volume of fruit, pulp weight and Weight ratio of fruit pulp to its stone as a physical characteristics, total and reducing sugar in fruit and concentration of potassium in date palm leaf as a chemical characteristics was significant.



Yield

The present results indicated that fertilization treatments caused significant increasing in average of production yield in date palm 'Sayer'. Treatment 6, consisted of using 700 g N, 500 g P₂O₅ and 1300 g K₂O for each tree, caused the highest average production yield (111.49 kg tree⁻¹) (table 3). Desirable effects of some macro elements upon date palm yields were reported by other researcher.

El-Hammady et al., (1991) found that the highest yield and fruit quality of 'Seewy' dates were obtained by adding 2 kg potassium sulfate/palm yearly.

Kassem et al. (1997) reported an increase in N and K contents of pinnate in date palm 'Zaghloul' due to increasing of potassium fertilizer rate, while Ca and Mg contents tended to decrease. Bamiftah (2000) recommended 2 or 3 Kg of potassium sulfate/palm/year for high yield and fruit quality. The present results may be attributed to the physiological role of potassium in enhancing many metabolic processes such as carbohydrate formation, translocation and accumulation

(Evans and Sorger, 1966 and Marchner, 1986). Archer (1985) reported that translocation of photosynthetic depended on cell potassium concentration. The obtained results are in close agreement with those found by (Abdalla et al. (1987) ; El-Hammady et al. (1991) ; Shawky et al. (1999) ; Harhash (2000) ; Abdel-Nasser et al.(2000) ; El-Shazly and Abdel-Nasser (2001). In addition to nitrogen, phosphorus is necessary for protein synthesis and energy carriers like ATP (adenosine tri phosphate) (Mengel 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 by (Karami, 2007; Sabbah, 1993; Bliss and Mathez 1983).

Fruit quality as physical characteristics

Some physical characteristics of fruit such as fruit diameter and stone weight were not affected by treatments. Therefore, the results related to mentioned parameters were omitted. But present results indicated significant increments in fruit quality such as fresh weight, length and volume of fruit, pulp weight and Weight ratio of fruit pulp to its stone as a result of fertilization with different levels of nitrogen, phosphorus and potassium. The results showed that fertilization treatments caused significant increasing in average fresh weight in date palm 'Sayer'. The highest average fresh weight of fruit (7.31 g) achieved by treatment 6, in comparison with other treatments (table 3). There were significant differences among treatments on pulp weight of fruit and higher pulp weight seen at treatment 6. Increment in pulp weight of fruit could be due to improving cell size or cell number by nutrient elements. These finding are in harmony with Sourour et al. (1998). They found pulp weight of date fruit in 'Samany'

cultivar had significant increasing by using organic plus inorganic fertilizers as comparison with organic alone. Dialami and pezhman (2005) reported foliar application of pure Potassium sulfate (5kg/1000L) caused increase yield and fruit quantity characteristics such as weight, length, diameter and volume of fresh fruit, weight, length, diameter and volume of stone and pulp to stone ratio of date fruit in 'Toory' cultivar. Fisher et al. (1959) mentions that Potassium is essential for fruit enlargement. In this experiment application of different levels of nitrogen, phosphorus and potassium caused significant increasing in fruit length. The highest amount of fruit length (4.26 cm) observed by applying of treatment 6 in comparison with other treatments (table 3). Weight ratio of fruit pulp to its stone was affected by using different fertilization treatments. The present results showed that treatments 2 and 6 caused the highest Weight ratio of fruit pulp to its stone (9.68 and 9.74) respectively. Similar results were obtained by (El- Deeb et al., 2000; Ismail, 1999) on 'Hayany' date palm cultivar. They reported that artificial nitrogen fertilizer significantly increases weight ratio of fruit pulp to its stone in fruit date. The fruit volume was affected by fertilization treatments. The highest amount of fruit volume (8.19 cm³) observed by applying of treatment 6 in comparison with other treatments (table 3). Overall, improvement occurred in the physical characteristics could be attributed to effects of nutrients on carbohydrate influx or plant growth regulators synthesis in growing fruits. Potassium plays an important role in, pH stabilization, osmoregulation, enzyme activation, protein synthesis, stomata 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 El-Hammady et al. (1991). Kein and zaid (2005) mention that Phosphorus plays a role in processes such as photosynthesis, respiration, vegetative growth, reproduction and maintenance of the genetic identity. It is also associated with cell division, root development and flowering.

Fruit quality as chemical characteristics

Some chemical characteristics of fruit such as pH, brix and acidity of fruit were not affected by treatments. Therefore, the results related to mentioned parameters were omitted. But results indicated significant increments in fruit quality such as reducing sugar and total sugar in fruits as a result of fertilization with different levels of nitrogen, phosphorus and potassium. Application of different levels of nitrogen, phosphorus and



potassium enhanced the amount of reducing sugar in date fruit in date palm 'Sayer' (table 4). Increasing in reducing sugar content could be due to necessity of mineral element for synthesis of sugar products and photosynthesis (Broschat, 1999; Mengalel and Kirkby, 1978). Other researcher (Bliss and Mathez, 1983; Sinclair et al., 1981) showed the desirable effect of different levels of nitrogen, phosphorus and potassium on increasing reducing sugar. The obtained results in this experiment, agreement with that found by Saleh (2009) on 'piarom' date palm. Total sugar percentage of date fruit, cultivar 'Sayer' increased significantly by application fertilization treatments. 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; 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 Rizk (1987) on date palm 'Samany' and date palm 'Hayany'; El-Hammady et al (1987) on date palm 'Swee'; El- Deeb et al (2000) on date palm 'Hayany'.

Mineral element concentration in date palm leaf

The results showed there were no significant difference between fertilization treatments in effect on nitrogen concentration in date palm leaf but, from the numerical viewpoint, treatment 6 and 1 showed the highest and the lowest nitrogen concentration, respectively (table 5). Also there were no significant difference between the treatments in effect on phosphorus concentration but, from the numerical viewpoint, treatment 10 caused the highest phosphorus concentration in

date palm leaf (780 mg kg⁻¹ dry wt.) and treatments 1 and 5 showed the lowest phosphorus concentration (490 mg kg⁻¹ dry wt.), respectively (table 5). According to table 5, application chemical fertilizers created significant changes in the potassium concentration in date palm leaf. The present results showed that treatments 2 and 6 caused the highest potassium concentration in the leaf of date palm (5808 and 6746 mg kg⁻¹ dry wt.) and treatment 1 showed the lowest potassium concentration (4550 mg kg⁻¹ dry wt.) respectively. Increasing leaf elemental contents due to fertilization may be attributed to the fact that using chemical fertilization can improve plant ability to uptake mineral nutrients. Improving plant uptake reflects on increasing vegetative growth and consequently improves efficiency for absorption and utilization of nutrients (Mangle and Kirkby, 1978; Abdel-Nasser and El-Shazly, 2001). These results are in harmony with those obtained by (Perica et al., 1994 ; Loupassaki et al., 1997). In general, in this experiment, it can be found that balanced application of nutrient elements such as nitrogen, phosphorus and potassium is required for optimum nutrition of date palm. Findings of this research showed that application of optimum nutrition of these essential elements had considerable effects on more yield production and improving of fruit quality in date palm 'Sayer'. So, determination of optimum levels of nitrogen, phosphorus and potassium fertilizers and application them for this cultivar is necessity and could bring considerable income to farmers. Therefore, in order to increase of yield and improving fruit quality, annually application of 700 g N, 500 g P₂O₅ and 1300 g K₂O for each tree to date growers in Khuzestan province is recommended.

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Table1. Soil sample analysis of experimental site.

Soil depth (cm)	EC (ds m ⁻¹)	pH	OC (%)	Available P and K	
				Available P (mg kg ⁻¹)	Available K (mg kg ⁻¹)
0-30	2.16	7.7	0.83	12	173
30-60	2.74	7.6	0.65	8	155
60-90	2.09	7.7	0.60	8	147

Table2. Water sample analysis of experimental site.

EC (µmhos cm ⁻¹)	pH	SAR	(meq L ⁻¹)				
			Na	Ca	Mg	CO ₃	HCO ₃
2150	7.75	8.32	22.03	6.8	7.2	0	6.25

Table3. Means comparison of effect of different treatments on yield, fresh weight, length, diameter, pulp weight and volume of fruit, weight of stone and Weight ratio of fruit pulp to its stone

Treatment	Yield (kg tree ⁻¹)	Fruit weight (g)	Fruit diameter (cm)	Fruit length (cm)	Fruit volume (cm ³)	Fruit pulp weight (g)	Stone weight (g)	Weight ratio of fruit pulp to its stone
T1	85.58b	6.86b	2.06a	3.62b	7.19b	6.68b	0.70a	9.29ab
T2	97.58b	7.02ab	2.05a	3.85b	7.49ab	7.20ab	0.70a	9.68a
T3	87.83b	7.01ab	2.05a	3.76b	6.83b	7.01ab	0.70a	9.28ab
T4	92.09b	7.01ab	2.03a	3.71b	7.11b	7.01ab	0.71a	9.05b
T5	86.17b	6.05ab	2.07a	3.76b	7.23b	6.05ab	0.69a	9.46ab
T6	111.4a	7.31a	2.11a	4.26a	8.19a	6.31a	0.71a	9.74a
T7	88.33b	6.05ab	2.07a	3.78b	7.48b	6.05ab	0.72a	9.35ab
T8	92.58b	6.9ab	2.03a	3.78b	7.02b	6.99ab	0.70a	9.24ab
T9	90.42b	7.12ab	2.04a	3.76b	6.94b	7.12ab	0.66a	9.52ab
T10	89.17b	6.99ab	2.05a	3.76b	7.30ab	6.99ab	0.70a	9.22ab
T11	88.5b	7.06ab	2.05a	3.72b	7.29ab	7.06ab	0.71a	9.38ab
T12	88.7b	7.11ab	1.99a	3.68b	7.19b	7.11ab	0.70a	9.37ab

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Table4. Means comparison of effect of different treatments on pH, acidity, brix, reducing sugar and total sugar in fruit.

Treatment	Fruit pH	Fruit acidity (%)	Fruit brix (%)	Reducing sugar of fruit (%)	Total sugar of fruit (%)
T1	6.00a	0.25a	77.88a	75.08a	66.86b
T2	6.04a	0.27a	78.79a	64.64b	72.78a
T3	6.00a	0.25a	76.54a	65.07b	65.73b
T4	5.59a	0.26a	77.45a	64.64b	67.03b
T5	6.01a	0.24a	76.78a	64.64b	65.84b
T6	6.11a	0.27a	78.05a	69.71ab	69.32b
T7	6.02a	0.26a	76.88a	65.07b	65.95b
T8	6.02a	0.25a	78.04a	61.00b	67.61b
T9	6.00a	0.25a	76.66a	65.85b	67.17b
T10	6.05a	0.25a	77.38a	67.08b	66.02b
T11	6.02a	0.26a	77.46a	67.08b	64.64b
T12	6.11a	0.24a	77.96 a	69.70ab	67.63b

Table5. Means comparison of effect of different treatments on concentration of nitrogen, phosphorus and potassium in leaf.

Treatment	Nitrogen (mg kg ⁻¹ dry wt.)	Phosphorus (mg kg ⁻¹ dry wt.)	Potassium (mg kg ⁻¹ dry wt.)
T1	8270a	490a	4550b
T2	8823a	522a	5808a
T3	8274a	509a	4695b
T4	8272a	499a	5126b
T5	8420a	490a	4918b
T6	9291a	521a	6746a
T7	8672a	498a	4972b
T8	8239a	492a	4800b
T9	8700a	500a	5000b
T10	8547a	780a	5000b
T11	8376a	490a	4729b
T12	8329a	492a	4671b