Advances in Environmental Biology, 4(3): 437-442, 2010
ISSN 1995-0756

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ORIGINAL ARTICLE

Yield and Fruit Physiochemical Characteristics of 'Kabkab' Date Palm as Affected by Methods of potassium Fertilization

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GH. Abdi: Yield and Fruit Physiochemical Characteristics of 'Kabkab' Date Palm as Affected by Methods of potassium Fertilization

ABSTRACT

This research aimed to evaluate the effects of different potassium fertilization method on yield and chemical, physical charactristics of date palm var. 'Kabkab'. Potassium fertilization prepared and applied by three methods:1-Control treatment (no fertilization) 2- Soil surface application of 3 kg/palm as potassium sulfate (48% K2O) 3-Foliar spray of potassium sulfate (%2) 4- potassium sulfate injection into the trunk of tree (%2). Higher and lower yield were obtained from trunk injection method and control, respectively. The greater amount of flash weight, fruit weight, fruit size, was resulted from injection method. Total soluble solids were the most in control; however, there were significant differences among treatments. The results of this study showed that mineral nutrients especially potassium, increased yield and quality of fruits in 'Kabkab' date palm and between different application methods of K, injection method was better than other methods. Because this method conveys the element directly to the respective parts of plant, using this method could help us to surmount the problem of absorption and transmission of K in date palm.

***Key words*:** Date palm, Kabkab, Foliar spray, Potassium, Trunk Injection

Introduction

Date palm (*Phoenix dactylifera* L.), a monocotyledonous and dioecious species belonging to the *Palmaceae* family, is widely cultivated in arid regions of the Middle East and North Africa [1]. In Iran date palm distributed in warm climate area especially in south, southwest and southeast areas and is one of the main export crops of Iran. The high land under date cultivation in Iran is in Boushehr province, especially Dashtestan region. This region is climatically apt to produce the most marketable date cultivar, 'Kabkab'. Area under cultivation of this cultivar has regularly increased in recent years because of its desirable taste, size and moisture and its important role to improve farmers, income. Producing high yield with best quality fruit related to many factors. Fruit trees and among them date palm, need optimum amounts of minerals for their best growth. Because of date palm can grow and produce under a wide rang of soil and climatic conditions, growers have mistakenly believed that it does not require much attention. The successful orchard management practices are directed toward obtaining a suitable yield with good fruit quality. One of the most important cultural practices in date palm orchards are fertilization. Proper application of fertilizers can increase quantitative, qualitative and economical output of date production in palm groves. However, this pattern of application depends on soil texture and the uptake rate of fertilizers. In addition, the nutrient requirements of the date palms differ greatly within each stage of tree life. Deficiency effects of some macro and micro elements on date palm yield, fruit qualities, fruit set and development, retention and fruit dropping and other related parameters were reported by some by many researchers [2,3,4]. Minimizing fertilizer application,

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leaching loss and maximizing nutrient uptake by crops are the main goals of researchers and growers [5]. Plants usually absorb water and nutrients by their roots, therefore fertilizers are traditionally applied into the soil [6]. While soil application can supply enough nutrients to improve plant production, it also causes world-wild anxiety about environmental contamination for nutrients leaching into ground water [7]. Increasing public concern, excessive nutrient loss from agricultural land encourages the researchers to find more efficient ways to apply fertilizers [5]. The power of plant leaves to absorb nutrients has resulted in the fact that the foliar application of nutrients becomes a recurrent method for supplying nutrients to plants [8]. Foliar fertilization has the advantage of low application rates, uniform distribution of fertilizer materials application rates, uniform distribution of fertilizer materials hidden hungers can easily be managed [9]. Trunk injection is one of the efficient methods of fertilizers application. In addition, the nutrient requirements of the date palms differ greatly within each stage of tree life. Applying the potassium element generally improves growth, yield and fruit quality of some date palm cultivars. EI-Hammady *et al*. [10] found that the highest yield and fruit quality of Seewy dates were obtained by adding 2 kg potassium sulphate/palm yearly. Kassem *et al*. [11] reported an increase in N and K contents of pinnae in Zaghloul date palm due to increasing of potassium fertilizer rate, while Ca and Mg contents tended to decrease. However, Shawky et al. [12] recommended 1.5 kg potassium sulphate/date palm each year. Also, Bamiftah [13] recommend 2 or 3 Kg of potassium Sulphate/palm/year for high yield and fruit quality, while, Harhash [14] recommended 750 g K2O (1.5 Kg potassium Sulphate) /palm/year. Regarding mentioned research, it is suggested that there is a significant relation between potassium fertilization and yield and chemical, physical characteristics of date palm in a way that using optimum amounts and methods of application of K fertilizers causes an increase in yield and develops fruit quality and quantity. The objective of this study is to investigate the effect of application methods of K fertilizer on yield, fruit chemical, physical characteristics of Kabakab date palm grown under Dashtestan region, Boushehr, Iran. Also, the amount of K as mentioned above per date/year was between 1.5-3 Kg in traditional application method. In this research 3 kg/palm was selected for traditional application method and compared with other methods with low amount of K fertilizer consumption.

Materials and Methods

The experiment was carried out during two successive growing seasons (2008 and 2009), 12 selected female uniform date palm trees (*Phoenix dactylifera* L.) of Kabkab cultivar, grown in Department of Agriculture and Natural Resource, Persian Gulf University, Iran. The trees were planted in sandy soil at 10 m apart. All the trees were of similar age (10 years old), uniform in growth, free from insects damage and diseases, and were subjected to the same management and cultural practices. Date palm trees were pollinated on March 5-15/2008 and 2009, by placing six fresh male strands on female spadix (flower cluster) center. Six flower clusters were used on each tree and a tree was subjected to one of the following treatments: 1- Control treatment (no fertilization 2- Soil surface application of 3 kg/palm as potassium sulfate (48% K2O) (added traditionally to soil surface) (Ks) 3- Foliar spray of potassium sulfate (%2) (Kf) 4- potassium sulfate injection into the trunk of tree (%2) (Kt). Solutions of above concentration of K fertilizer were prepared with distilled water. For trunk injection each tree drilled with a hand drill 1.5 m in height and 30 cm depth with 45 hermitages to down. Treatments were conducted 10 days after pollination (DAP) during two consecutive growing seasons (2008-2009). Clusters were protected from contamination by special practice. Ten strands were randomly selected per each replicate (5 bunchs for each tree), from the 40-50 strands that composed a bunch, to determine following fruit characteristics in selected time:

Fruit chemical characters:

Total soluble solids: The percentage of TSS was determined in the fruit juice using zice refractometer [15].

Fruit acidity: fruit acidity was determined according to A.O.A.C.(1995) and the titrable acidity was calculated as citric acid [16].

Total soluble sugars and reducing soluble sugers: It was determined according to Smith *et al*., and Nelson and Somogy methods [17,18]. The percentage was calculated per dry weight.

Non-reducing sugars: It was determined by the difference between total and reducing sugars.

Fruit physical characters:

Samples of 50 fruits per each palm, 10 fruits were taken randomly from each bunch (replicate) to determine fruit weight, flesh weight, seed weight (g), seed/fruit %, fruit dimensions (length and diameter "mm"), fruit length/diameter ratio, fruit size (cm3).

Percentage of fruit set at 45, 90 and 135 day after pollination (first, second and third stages of fruit development respectively). Each bunch was tagged and labeled and the respective percentage of fruit set per selected strand was determined by counting the

number of fruit and dividing it by the total number of the twigs on the respective strands. Bunches were harvested 180 days after pollination. Each bunch was then weighed and all its respective fruits on all its strands were picked and separated into ripening and non ripening fruits, the percentage of ripening fruit was determined by weighing of ripe fruit and divided by the total weight of each replicate [19]. Total yield per tree was determined by harvesting the 5 bunches from each tree, adding the value to the weight of fruit harvested for fruit flesh, fruit dry matter and total soluble solid samples.

Experimental design and Statistical analysis:

The experiment was arranged in randomized complete block design with 4 treatments and each treatment contains 3 replications. Treatments means where compared using the new Duncan Multiple Range Test (DNMRT) at 5% probability level.

Results and Discussion

Vegetative growth:

Results shown in Table (1) illustrate that K-fertilization significantly affected the vegetative growth of date palm i.e. number of new growing leaves and number of bunches per palm for both growing seasons. Increasing the K-fertilization rate from zero (control) to 3 Kg K2SO4/palm/year (traditional method) increased the No. of new growing leaves from 14.70 to 17.86 and from 17.78 to 21.61 for both seasons, respectively. The same trend was noticed with No. of bunches per palm in which it increased from 4.50 to 7.13 and from 5.15 to 8.11 for both seasons, respectively. Also, the same results obtained about other method of k application. The results also, indicated that the difference between the different methods of K-fertilization was not significant, but it differed from the control and other application method. In general, application of K-fertilization tends to increase the vegetative growth of palm trees. The present results are in agreement with those obtained previously by many investigators. Montasser *et al*. [20] recommended 2 or 3 Kg of potassium sulphate to increase the vegetative growth of Seewy date palm. Also, Shawky [4], Harhash [13], Bamiftah [12], Abdel- Nasser et al.[21] and Abdel-Nasser and El-Shazly [22] supported this result.

Fruit setting, fruit drop percentage and yield per palm:

Foliar spray and soil fertilization of K did not effect fruit set percentage of Kabkab date palm trees at all three stages of fruit development (45, 90 and 135 DAP) during two successive growing seasons (2008, 2009). K injection increased slightly fruit set % at the second or third stage of fruit development during first or first and second growing season respectively as compared with control (Table 2). The fruit set (%) of Kabkab date palm tended to be high in the first stage of fruit development, then progressively decreased with fruit age throughout the two growing successive seasons. Similar responses on fruit drop percentage were observed, in other hand there are not any significant response between treatments. The above mentioned results indicates that K not have effective role in fruit dropping. Singh and Saut Ram, [23], Babu *et al.*, [24], and Khan *et al.,* [25], reported that fruit retention of many other fruit trees related to the calcium and zinc nutrition. These materials are required for building plant structure or preventing the abscission layer formation and consequently, the reduction in pre-harvest fruit dropping [26]. Between treatments injection treatment showed the highest amount of yield in compare with other treatments and control. The fruit yield was increased from 91.37 at control to 112.4 Kg/palm in the first season in injection method. The corresponding values for the second season were from 97.13 to 115.37 Kg/palm. The increment in yield may be attributed to the increase in number, and length of growing leaves. Consequently, an increase will be expected in the photosynthesis rate. In addition, the present results may be attributed to the physiological role of potassium in enhancing many metabolic processes such as carbohydrate formation, translocation and accumulation [27,28]. Archer [29] reported that translocation of photosynthates depended on cell potassium concentration. The obtained results are in close agreement with those found by Abdalla *et al*. [30], EI-Hammady *et al*. [10], Shawky et al. [13], Bamiftah [12] and Harhash [14], Abdel-Nasser et al. [21] and El-Shazly and Abdel-Nasser [22]. A tentative explanation for the increased yield per palm in table 1 may be the injection of K into the trunk, conveys the element directly to the respective parts of plant, using this method could help us to surmount the problem of absorption and transmission of K in date palm. Presence of sufficient amounts of available K causes an increase in metabolism in plant. Also, K plays a crucial role in processes in plants that require electron transfer reactions, including photosynthesis and nitrogen assimilation (activation of nitrate reductase). One of the most noticeable effects of K deficiency on photosynthesis is a decrease in Co2 fixation and Ion translocation. K limitation also reduces the synthesis of proteins of the photosynthetic apparatus. In addition, the functioning of the stomata apparatus is affected by K. As a consequence, photosynthetic efficiency is reduced in iron-limited cells. K is also a regulation component of the cells that are involved in ion uptake, ion substitution, increasing osmotic pressure in vacuole [27].

Table 1: Effect of different K application methods on vegetative growth characteristics of Kabkab date palm.

Treatments	Number of leaves		Number of branch	
	2008	2009	2008	2009
Control	14.7 b†	17.16b	4.5 b	5.83b
K s	17.86 a	21.44a	5.5 a	7.95a
K f	17.55`a	20.11a	5.5 a	7.54a
K t	18.46a	20.33a	5.94a	7.53a

†Means within a column followed by the same letters are not significantly different by new Duncan's multiple range test ($P > 0.05$).

Table 2: Effect of different application method of K on fruit Setting, fruit drop Percentage and yield per palm of Kabkab cultivar.

Treatments	Fruit Setting %						Fruit drop %		Yield / Palm(Kg)	
	45		90		135					
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Control	80 a †	75.2 a	45b	37 a	35 b	36b	19b	43.5a	91.37 c	97.36c
K s	79 a	75 a	46 b	41 a	40.2 b	41 b	19.3b	22.25b	103.31b	104.07b
K f	80.1 a	79.2 a	75.1 a	45a	61 a	59 a	26.24a	26.26b	103.5b	105.92b
K t	77 a	76.1 a	55.1 b	45 a	33.1 b	61 a	21.57b	20.14b	112.4 a	115.37a

†Means within a column followed by the same letters are not significantly different by new Duncan's multiple range test ($P > 0.05$).

Table 2: Effect of different K application method on some physical characters of Kabkab date Fruits at the end of khalal stage.

Treatments	Fruit weight (gm)		Fruit size (cm3)		Flesh weight (gm)	
	2008	2009	2008	2009	2008	2009
Control	16.94b†	18.16b	18.07b	18.83b	14.47b	15.46b
K s	21.13a	19.44a	20.39a	21.85a	17.48a	16.67b
K f	20.51b	20.99a	19.55a	23.59a	14.89b	19.96a
K t	21.46a	22.33a	19.94a	22.53a	16.77a	20.95a

†Means within a column followed by the same letters are not significantly different by new Duncan's multiple range test (P > 0.05).

Table 3: Effect of different K application Methods on Total Soluble Soilds and Sugars of Kabkab date fruits, at the end of Khalal stage.

Treatments	T.S.S. %		Reducing Sugars %		Non – reducing Sugars %		Total Sugars	
	2008	2009	2008	2009	2008	2009	2008	2009
Control	32.6a†	30a	70.20a	67.4c	8.10b	4.31b	78.30b	71.71c
K s	32.6a	30a	72.70a	80.46a	11.8a	6.6a	84.5 a	87.06a
K f	31.6a	29a	71.1 a	75.5b	10.4 a	5.77a	78. 5b	85.95a
K t	30. 3a	31a	72.85a	78.6 b	12.05a	10.11a	84.9 a	88.71a

†Means within a column followed by the same letters are not significantly different by new Duncan's multiple range test ($P > 0.05$).

Fruit weight, size and flesh weight: Results in Table (2) reveal that average of fruit weight and flesh weight significantly increased during both seasons of the study, whereas the same trend was observed in the on-year of bearing; however the differences were not significant in the off-year of bearing. The different treatments of K application methods showed similar effects on fruit physical properties. The lowest amount fruit physical properties were observed in control treatment. These results reflect the positive effect of K on palm trees during both on-year and off-year of bearing. there were almost no statistical differences between fruit average weights in k treatments. But, all treatments showed significance difference with control treatment (No fertilizer). The highest amounts were seen in injection method. It can be explained with the effect of K injection on increasing plant K concentration that enhances methabolism rate in plant, consequently. Increasing fruit average weight due to K injection into trunk of tree has also reported by others. Weight ratio of fruit pulp to its stone showed no statistical differences in different treatments, except for injection method. Totally, K injection to the trunk of the tree was more effective than the other K fertilization methods. As it was discussed in previous paragraph, K injection increased fruit average weight, so, the weight ratio of fruit pulp to its stone will be risen with using K via injection into the trunk of tree. Therefore, injection of K to the trunk of date palm can be the best recommendation to achieve desirable results such as increment in plant K content. Potassium injection into the trunk of tree can supply adequate amounts of this essential element for plant regardless of high amounts of Na, and NH4 pH of soil that can cause disorder in absorption and translocation of elements in plant.
Soil surface application of K showed the lowest fruit average weight than foliar and injection method except control treatment. The 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 [31]. Moreover, potassium is an important solute in expanding cells [27]. These results are in agreement with those obtained by EI-Hammady *et al.* [10], Shawky *et al*. [13], Harhash [14] and Bamiftah [12].

Seed weight, fruit diameter, seed/fruit ratio, fruit

length/diameter ratio and fruit acidity:

No significance differences were detected in Seed weight, fruit diameter, seed/fruit ratio, fruit acidity and fruit length/diameter ratio during both seasons (data not shown). But, the highest rate of Seed weight, fruit diameter, seed/fruit ratio, fruit length/diameter ratio and fruit length during both seasons were obtained in injection method and the lowest rate were detected in control treatment.

Chemical characteristics of date fruit:

Results indicated that the acidity percentage between treatments were not significant in two seasons (data not shown).The results in Table (3) clearly indicate that the effect of treatments included K application method were apparent at the first season of the study on T.S.S., where the increase was not significant. Also, the increase in the second season was not significant. Fruit sugar percentage was increased in all treatments as compared with control. Statistically, treatments showed no significant differences with each other in first and second season about reducing and non reducing sugers except for control. Among treatments, injection method showed the highest amount. As mentioned above application of K showed positive effects on chemical properties of Kabkab date palm. These results are due to the fact that potassium activates the enzymes involving in sugar biosynthesis and helps in translocation of sugars [28,29]. In addition, Suelter [32] 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 Abdalla *et al.* [30], EI-Hammady *et al*. [10], Attalla *et al*. [33], Harhash [14] and Bamiftah [12]. Therefore, it seems reasonable that injection works better than foliar and soil surface method.

Conclusion

According to the results of this investigation, The results application mineral nutrients especially potassium, increased yield and quality of fruits in 'Kabkab' date palm and between different application methods of K, injection method was better than other methods. Because this method conveys the element directly to the respective parts of plant, using this method could help us to surmount the problem of absorption and transmission of K in date palm.

Acknowledgement

This study was supported by Persian Gulf Research Center (PGRC) and Persian Gulf Research and Studies Center (PGRSC).We thanks Mr. Zarei and Mr Bagheri (Department of Horticultural Science, PGU University) for kindly help.

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