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Yield and Fruit Physiochemical Characteristic of 'Kabkab' Date Palm as Affected by Methods of Iron Fertilization

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Abstract: This research aimed to evaluate the effects of different iron fertilization method on yield and chemical, physical charactristics of date palm var. 'Kabkab'. Research treatments were consisted of: 1-Control treatment 2- Soil surface application of Fe 3-Foliar spray of Fe 4-Fe injection into the trunk of tree. Higher and lower yield were obtained from H 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 iron, increased yield and quality of fruits in 'Kabkab' date palm and between different application methods of Fe, 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 Fe in date palm.

Key words: Date palm · Kabkab · Iron · Foliar spray · 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, 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 auses 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

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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. Iron deficiency chlorosis is a worldwide problem in crop production on calcareous soils [10, 11]. Fe deficiency or its less mobility in plant prevents chlorophyll formation and causes chlorosis. Fe deficiency also can cause decrease in assimilation and decline in yield [12]. A research done on the date palm showed that Fe injection into the trunk of tree caused yield increase [13]. It was also reported that injection of Fe into the trunk of date palm, caused a meaningful increase in Fe concentration in leaves, as well as date yield [13, 14]. Other researchers have also showed that Fe deficiency was removed in some trees such as olive and peach after Fe injection into their trunks [15]. Peryea and Kammereck (1997) observed that trunk injection of iron could eliminate leaf chlorosis in iron-deficient pear trees [16]. Desirable effects of using iron chelate on chlorosis removal have also reported in citrus trees [17]. Regarding mentioned research, it is suggested that there is a significant relation between iron fertilization and yield and chemical, physical characteristics of date palm in a way that using optimum amounts and methods of application of Fe 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 Fe fertilizer on yield, fruit chemical, physical characteristics of Kabakab date palm grown under Dashtestan region, Boushehr, Iran.

MATERIALS AND METHODS

The experiment was carried out during two successive growing seasons (2008 and 2009), 7 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 Fe (200 mg/l) (added traditionally to soil surface) 3-Foliar spray of Fe (200 mg/l) 4-Fe injection into the trunk of tree (200 mg/l). Solutions of above concentration of Fe fertilizer was prepared with distilled water. For trunk injection each tree drilled with a hand drill 1.5 m 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 [18].

Fruit Acidity: fruit acidity was determined according to A.O.A.C. (1995) and the titrable acidity was calculated as citric acid [19].

Total Soluble Sugars and Reducing Soluble Sugers: It was determined according to Smith *et al.* and Nelson and Somogy methods [20, 21]. 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 [22]. 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

Fruit Setting, Fruit Drop Percentage and Yield per Palm: Foliar spray and soil fertilization of Fe 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). Fe 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 1). 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 Fe 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. A tentative explanation for the increased yield per palm in Table 1 may be the injection of iron 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 Fe in date palm. Presence of sufficient amounts of available Fe causes an increase in photosynthesis and carbohydrate motion in plant. This makes more production yield [27]. Also, Iron plays a crucial role in processes in plants that require electron transfer reactions, including photosynthesis and nitrogen assimilation. One of the most noticeable effects of iron deficiency on photosynthesis is a decrease in cellular content of chlorophyll (chl) a and other pigments involved in light harvesting [10]. Iron limitation also reduces the synthesis of proteins of the photosynthetic apparatus, like the D1-protein in photosystem II (PSII) [28]. In addition, the functioning of the Photosynthetic Electron Transport (PET) chain is affected by a decrease in ironsulphur complexes, e.g. ferredoxin. As a consequence, photosynthetic efficiency is reduced in iron-limited cells. Iron is also a structural component of the metallo-enzymes that are involved in nitrate uptake, nitrite and nitrate reductase [10]. Yield increase with Fe injection to the trunk of tree was consistent with others' founds [13, 16]. Undoubtedly, Fe injection is not the only way to overcome the deficiency of this element and there are some other effective ways to do this [12, 29, 30].

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 Fe 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 Fe on palm trees during both on-year and off-year of bearing. Similar results were reported by Moghimi [31]. There were almost no statistical differences between fruit average weights in Fe treatments. But, all treatments

Table 1: Effect of different application method of Fe on fruit Setting, fruit drop Percentage and yield per palm of Kabkab cultivar

	Fruit Setting (%)									
	45		90		135		Fruit drop (%)		Yield / Palm (kg)	
Treatments	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Control	79 a	74.2 a	63b	39 a	36 b	37b	21b	41.53a	98.8b	60.36c
Fe s	77 a	73 a	49 b	42 a	41.2 b	42 b	20.3b	21.35b	107.31a	107.07a
Fe f	81.2 a	78.2 a	75.1 a	44a	65 a	61 a	27.94a	27.46b	95.31b	95.92b
Fe t	79 a	77.1 a	53.1 b	42 a	34.1 b	63 b	22.97b	21.24b	85.67b	107.22a

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 on some physical characters of Kabkab date Fruits at the end of khalal stage

	Fruit weight (gm)		Fruit size (cm^3)		Flesh weight (gm)	
Treatments	2008	2009	2008	2009	2008	2009
Control	17.94b	19.06b	18.07b	19.83b	14.77b	15.36b
Fe s	21.13a	19.44b	21.59a	21.25a	17.48a	16.77b
Fe f	18.51b	21.99a	19.45a	23.29a	14.89b	19.26a
Fe t	20.46a	22.33a	19.64a	22.83a	16.77a	20.75a

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 Fe application Methods on Total Soluble Soilds and Sugars of Kabkab date fruits, at the end of Khalal stage

	T.S.S. (%)		Reducing Sugars (%)		Non-reducing Sugars (%)		Total Sugars	
Treatments	2008	2009	2008	2009	2008	2009	2008	2009
Control	33.5a	30a	70.40a	68.97c	8.20b	4.34b	78.60b	73.31c
Fe s	32.3a	31a	76.74a	80.46a	11.94a	6.66a	88.68a	87.12a
Fe f	32.67a	29a	71.79a	74.5b	7.46b	5.57a	79.25b	80.08b
Fe t	30.33a	28a	72.32a	74.59b	12.66a	6.01a	87.98a	80.6b

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

showed significance difference with control treatment (No fertilizer). The highest amounts were seen in injection method. It can be explained with the effect of Fe injection on increasing plant Fe concentration that enhances photosynthesis rate in plant, consequently [27]. Increasing fruit average weight due to iron injection into trunk of tree has also reported by others [14]. Weight ratio of fruit pulp to its stone showed no statistical differences in different treatments, except for injection method. Totally, Fe injection to the trunk of the tree was more effective than the other Fe fertilization methods. As it was discussed in previous paragraph, Fe injection increased fruit average weight, so, the weight ratio of fruit pulp to its stone will be risen with using Iron via injection into the trunk of tree. Therefore, injection of Fe to the trunk of date palm can be the best recommendation to achieve desirable results such as increment in plant Fe content. Iron injection into the trunk of tree can supply adequate amounts of this essential element for plant regardless of high amounts of CaCO3 and high pH of soil that can cause disorder in absorption and translocation of elements in plant [15]. Soil surface application of Fe showed the lowest fruit average weight than foliar and injection method except control treatment.

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 (2) clearly indicate that the effect of treatments included Fe application method were apparent at the first season of the study on T.S.S., where the increase was significant, but the increase in the second one was not significant. Fruit sugar percentage was increased in all treatments as compared with control. Statistically, treatments showed no significant differences with each other except for control. Although, from the numeral viewpoint, treatments 6 and 8 were caused the highest fruit sugar concentration with an increase of about 18% in comparison with control, whereas, treatments 3 and 5 showed the least amounts (Figure 3). Irons have been shown to have important role in photosynthesis in plants [32, 33] and sugar is the main product of photosynthesis. Injection of a solution containing Fe with acidic pH into the trunk of tree, not only supplies enough amounts of available Fe for photosynthesis, but also improves absorption and translocation of other nutrient elements such as Zinc, Copper, Manganese and phosphorus by reducing the pH

of sap [34]. Therefore, it seems reasonable that injection works better than foliar and soil surface method. Methods commonly used to correct iron chlorosis include one or more of the following procedures: acidifying the soil with large quantities of sulfur; applying iron chelates in a trench around each tree; and using foliage sprays containing iron. Usually these treatments only partially correct the deficiency and either the materials or the labor required is costly.

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