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Yield and chemical composition of 'Piarom' date palm as affected by levels and methods of iron fertilization

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Abstract

This research was conducted in order to study the effects of iron fertilization on yield and chemical composition of date palm var. 'Piarom', on 54 trees in Haji-Abad research station of Hormozgan Province. Trees were 12 years old and research treatments were consisted of: 1-Control treatment 2- Soil surface application of Fe in two levels 3-Application of Fe as localized placement method (Chalkood method) in two levels 4-Fe injection into the trunk of tree in four levels. The experiment was performed as a randomized complete blocks design with nine treatments and three replications in four years. Trees were pollinated according to the custom of the region and irrigated through drip system. Fruit thinning was done with extra clusters deletion regarding the ratio of eight leaves to one cluster. Production was harvested and weighted each year in October, the second half. Chemical and physical analysis of leaves and fruits were also done. Obtained raw data were analyzed statistically and means were compared with each other via Duncan's multiple range test using MSTATC software. Results showed that in most cases, injection of 25 g $FeSO_4$ tree^{-1} into the trunk caused the best results. Other injection treatments were placed in second class. Localized placement of iron fertilizer was the next treatment from the viewpoint of desirable effects. Finally, soil surface application appeared as an inapt method because it was statistically similar to control treatment, in most cases.

Keywords: Fe injection; Localized placement; Soil surface application

Introduction

The whole land under date cultivation in Iran is estimated about 185000 hectares (Anonymous, 2005) that over 37000 hectares of it is allotted to Hormozgan province, especially Haji-Abad region (Anonymous, 2006). This region is climatically apt to produce the most marketable date cultivar, 'Piarom'. 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.

Fruit trees and among them date palm, need optimum amounts of minerals for their best growth. Proper application of macro and micro nutrient fertilizers is necessary to increase quantitative, qualitative and economical output of date production in palm groves. 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 (Malakouti and Tabatabaei, 1999).

A research done on the date palm showed that Fe injection into the trunk of tree caused yield increase (Abo-Rady et al., 1987). 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 (Abo-Rady et al., 1987; Rasouli and Malakouti, 1999). Other researchers have also showed that Fe deficiency was removed in some trees such as olive and peach after Fe injection into their trunks (Fernandez et al., 1993). Peryea and Kammereck (1997) observed that trunk injection of iron could eliminate leaf chlorosis in iron-deficient pear trees. Desirable effects of using iron chelate on chlorosis removal have also reported in citrus trees (Banuls et al., 2003). Regarding mentioned research, it is suggested that there is a significant relation between iron fertilization and yield and chemical composition of date palm in a way that using optimum amounts of Fe fertilizers causes an increase in yield and develops fruit quality and chemical composition of leaves. The objective of this study was to examine the above mentioned hypothesis in 'Piarom' date palm in Hormozgan province. For this purpose, we studied the effects of using different methods and levels of iron fertilizations on date yield and some other plant responses such as fruit average weight, fruit length, Fe and Zn content of leaves and total sugar percentage of fruits.

Materials and methods

Present research was conducted on 54 date palm var. 'Piarom' in Haji-Abad research station in 4 years. The experiment was performed on 12 years old trees as a randomized complete blocks design consisting 9 treatments and 3 replications with two trees in each treatment.

Research treatments including three fertilization methods in various levels were applied as follows:

1: Control treatment
2: Soil surface application of 100 g Fe-EDDHA tree^{-1} in the form of a strip around the trunk of trees
3: Soil surface application of 200 g Fe-EDDHA tree^{-1} in the form of a strip around the trunk of trees
4: Localized placement (Chalkood) of 1 kg $FeSO_4$ tree^{-1}
5: Localized placement (Chalkood) of 2 kg $FeSO_4$ tree^{-1}
6: Injection of 2 liters solution with zero concentration of Fe and a pH of 3.5
7: Injection of 25 g $FeSO_4$ tree^{-1} as 2 liters solution with a pH of 3.5
8: Injection of 50 g $FeSO_4$ tree^{-1} as 2 liters solution with a pH of 3.5
9: Injection of 100 g $FeSO_4$ tree^{-1} as 2 liters solution with a pH of 3.5

Besides, following necessary fertilizers were uniformly used for each tree: 2.5 kg NPK fertilizer (named as complete macronutrients fertilizer), 1 kg powdery sulfur fertilizer and necessary amounts of animal manure for filling pits. Meanwhile, this fertilizer was added to the soil in 4 pits around the trees with 70 cm in depth and 40 cm in diameter. Trees were pollinated with fresh pollens, regarding the custom of the region. The irrigation method was drip system. Fruit thinning was done with extra clusters deletion regarding the ratio of 8 leaves to 1 cluster in the kimri stage (in the kimri stage, fruits are hard and crisp and bright green in color, with a moisture content of 84-85.5%). Production was harvested and weighted each year in October, the second half. Physical and chemical properties of fruit such as length, average weight, weight ratio of fruit pulp to it's stone and fruit total sugar percentage were measured in laboratory. Also, concentrations of Fe and Zn in leaves were determined.

Obtained raw data were statistically analyzed. Means were compared using Duncan's multiple range tests via MSTATC software.

Results and discussion

Injection of 25 g $FeSO_4$ tree^{-1} (treatment 7) caused the highest yield. Treatments 5, 8 and 9 placed next to the treatment 7. The least amount of yield was measured in treatments 1 to 4 (Figure 1). So, soil surface application had the least effect on increasing yield, as well as using 1 kg $FeSO_4$ tree^{-1} as chalkood. But, applying 2 kg $FeSO_4$ tree^{-1} as chalkood resulted considerable yield rise. In calcareous soils like our soils in Hormozgan province, there is low amounts of plant available Fe, despite the large amounts of total Fe in them because of the effect of high pH on reducing Fe availability and so, iron uptake by plant becomes low.

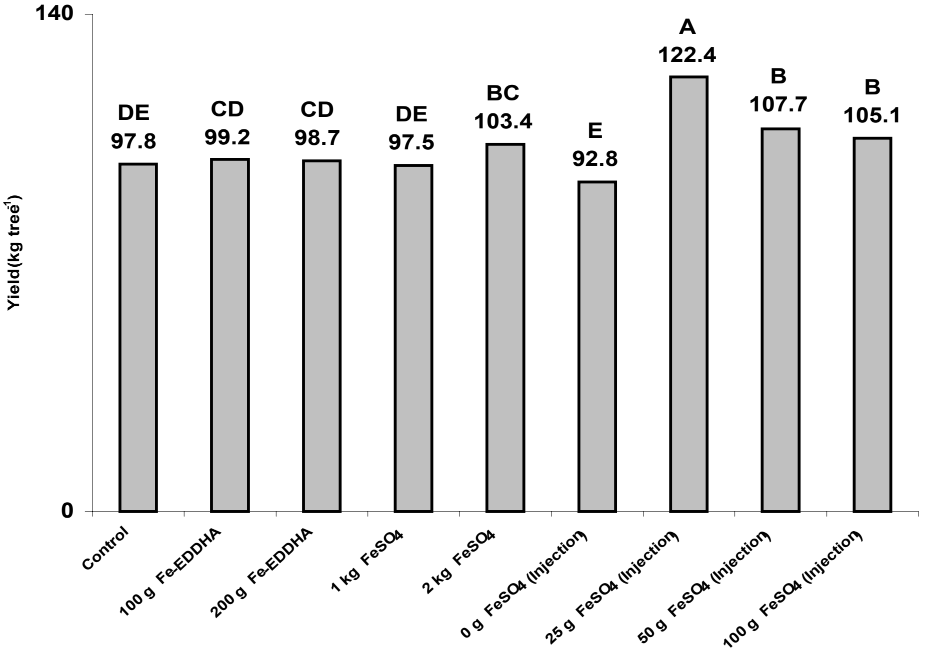

Figure 1. Effect of treatments on date yield.

Since 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 (Mengel and Kirkby, 1978). Yield increase with Fe injection to the trunk of tree was consistent with others' founds (Abo-Rady et al., 1987; Peryea and Kammereck, 1997). 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 (Tindall et al., 1996; Malakouti and samar, 1998; Malakouti and tabatabaei, 1999).

Fruit length was nearly the same in most of treatments, statistically. But, from the numeral viewpoint, treatment 7 showed the most length of the fruit that is 40.39 mm. The least length of the fruit was measured in treatments 1 to 3, that is, control treatment and those which Fe-EDDHA was applied as soil surface method (Table 1). Similar results were reported by Moghimi (1998).

Table 1. Effects of treatments on some plant responses.

Treatment No	1	2	3	4	5	6	7	8	9
Fruit length (mm)	36.99cd*	36.37d	37.62bcd	38.38bc	39.18ab	38.41bc	0.39a	39.23ab	38.38abc
Fruit average weight (g)	8.09c	7.93c	8.09c	7.90c	8.21c	8.32bc	8.95a	8.80ab	8.39bc
Ratio of fruit pulp to stone	6.51d	6.65cd	6.86cd	6.72cd	6.78cd	7.14bc	7.82a	7.52ab	7.02bcd
Leaf Zn content (mg kg^{-1} dry wt.)	4.18bc	4.07bcd	3.50de	3.71cde	3.69cde	3.26e	4.37ab	3.70cde	4.80a

*Values followed by same small letter in each row, are not significantly different at $P \leq 0.05$.

There were almost no statistical differences between fruit average weights in treatments 1 to 6. The highest amounts were seen in treatments 7 and 8. Although, treatment 7–injection of 25 g $FeSO_4$ to the trunk of each tree – showed the greatest number. Treatment 9 (injection of 100 g $FeSO_4$ $tree^{-1}$), has statistically the same place as treatments 1 to 6 (Table 1). Anyway, injection of 25 g $FeSO_4$ $tree^{-1}$ and other injection treatments had the best effects. It can be explained with the effect of Fe injection on increasing plant Fe concentration that enhances photosynthesis rate in plant, consequently (Mengel and Kirkby, 1978). Increasing fruit average weight due to iron injection into trunk of tree has also reported by others (Rasouli and Malakouti, 1999).

Weight ratio of fruit pulp to its stone showed no statistical differences in different treatments, except for injection method. Treatment 7 resulted the highest ratio. Treatment 8 was the same as treatment 7, statistically. Treatments 6 and 9 were also similar to treatment 8. Totally, Fe injection to the trunk of the tree was more effective than the other Fe fertilization methods. Rest of treatments showed no significant differences with each other.

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.

The highest amounts of Fe concentration in date leaves were seen in treatments 7 and 9 in common. Next to them are treatments 5 and 8. Therefore, injection of $FeSO_4$ 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 $CaCO_3$ and high pH of soil that can cause disorder in absorption and translocation of elements in plant (Frenadez-Escobar et al., 1993). Treatment 4 and then treatments 1 to 3 and 6 showed less amounts of leaf Fe concentration, statistically (Figure 2). The other researchers have reported increase of Fe concentration in date leaves due to the Fe injection (Abo-Rady et al., 1987). Some other research also showed that the content of Fe in plant leaves increased due to Fe application through the localized placement method (Malakouti and samar, 1998; Malakouti and Tabatabaei, 1999). Soil surface application of FeEDDHA caused the least increase in Fe concentration of leaves.

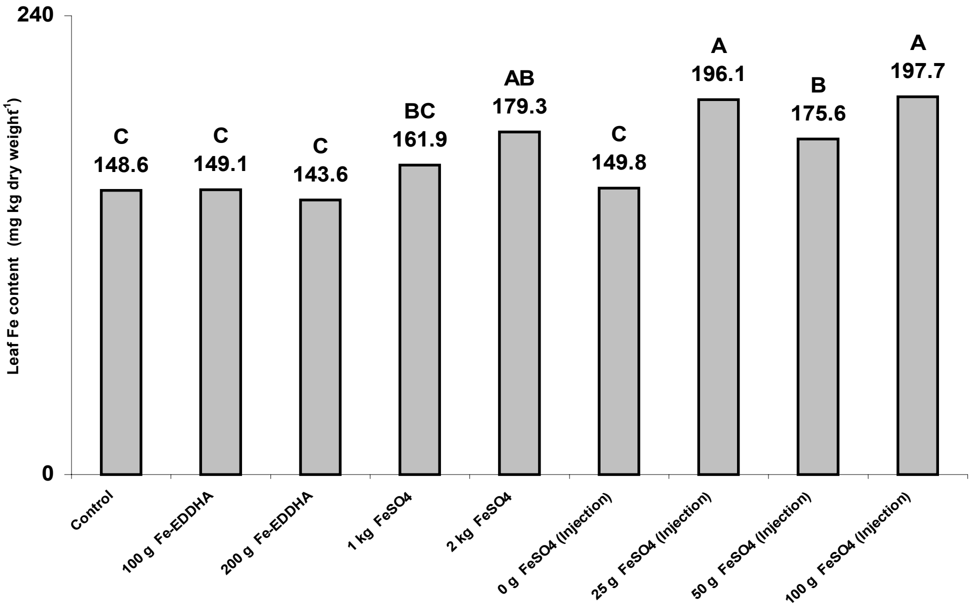

Figure 2. Effect of treatments on leaf Fe content in date palm.

Treatments 7 and 9 caused the most increasing in Zn concentration of date leaves, statistically. However, treatment 9 (injection of 100g $FeSO_4$ into the trunk of each tree) was the most. The least amount of Zn concentration in leaves was also allotted to treatment 6, that is injection of a solution with a Fe concentration of zero (Table 1). Other treatments showed less contents of Fe in leaves, in common. Increase of Zn concentration in treatments 7 and 9 is probably due to the high amounts of Fe concentration in these treatments. Antagonistic effect of Fe causes a decline in phosphorus concentration in leaves and then, Zn concentration is increased because of its reverse relation with phosphorus concentration (Bilsborough, 1993).

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 (Archer, 1985; Nijjar, 1990; Zarrinkafsh, 1992) and sugar is the main product of photosynthesis. Injection of a solution containing $FeSO_4$ 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 (Taiz and Zeiger, 1998). Therefore, it seems reasonable that injection works better than Chalkood.

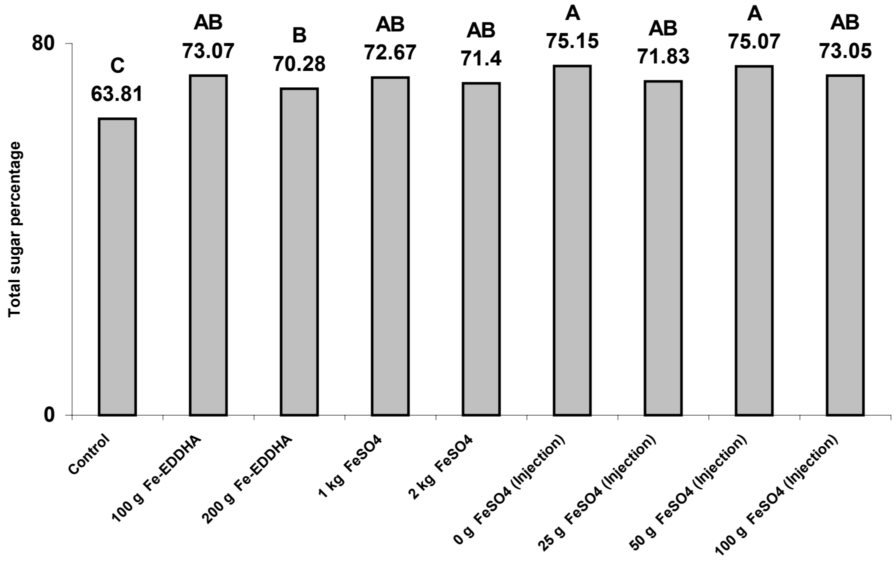

Figure 3. Effect of treatments on total sugar percentage.

Conclusions

A precise investigation on obtained results showed that in most cases, injection of 25 g $FeSO_4$ tree^{-1} caused the best results. Although, injection of 50 and 100 g $FeSO_4$ tree^{-1} also showed similar results with no statistical differences. Totally, the most desirable effects were seen in the injection treatments, but the treatment 25 g $FeSO_4$ tree^{-1} can be the best recommendation because of its similarity with treatments 50 and 100 g $FeSO_4$ tree^{-1}. It is necessary to say that injection of solution with a zero concentration of $FeSO_4$ didn't cause any good results and was often similar to control treatment, statistically. The next proper method was localized placement (Chalkood) of 2 kg $FeSO_4$ $tree^{-1}$, although 2 kg $FeSO_4$ $tree^{-1}$ did'nt usually work well. Injection method was better than Chalkood because there is large quantities of calcium carbonate in our soils that can prevent absorption and transmission of some nutrient elements in plant. But in injection method, destination parts of plant such as leaves, receive fertilizers solution regardless of soil $CaCo_3$ content. Soil surface application of Fe-EDDHA appeared as an improper fertilization method and allotted the lowest grade to itself, as well as the control treatment. In recent method, fertilizers mainly remain unusable on soil surface, whereas, nutrients should be present near the root to be absorbed more efficiently.

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