Is Trunk Injection More Efficient Than Other Iron Fertilization Methods in Date Palms Grown in Calcareous Soils?

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***Abstract*—The effect of different iron fertilization methods on yield and some fruit quality parameters of the date-palm variety 'Piarom' was studied in a calcareous soil of Hormozgan Province in Iran. The trees were 12 years old and the treatments comprised of: 1 - control, 2 - surface placement of Fe-EDDHA in the soil with two levels, 3 - deep placement of $FeSO_4$ in the soil (Chalkood method) with two levels, and 4 - injection of $FeSO_4$ solution into the trunk of trees with four levels. The experiment was accomplished as a randomized complete blocks design with nine treatments and three replications during four years Injection of 25 grams of $FeSO_4$ into the trunk resulted in the highest yield, having considerable differences with the other treatments. The maximum concentration of iron, as well as the highest Brix index and reducing sugars content were obtained in trees injected with a solution of $FeSO_4$, showing no significant differences between different levels of $FeSO_4$. Therefore, it can be concluded that trunk injection is a more efficient method for iron fertilization of date palms grown in calcareous soils. Moreover, the best injection level was 25 grams $FeSO_4$ tree^{-1}.**

***Index Terms*—date palm, iron fertilization, Piarom, trunk injection**

I. Introduction

The date palm cultivated area in Iran is estimated about 180000 hectares [1]. The area under date palm cultivation in Hormozgan province is about 32000 hectares with total production of more than 146000 tons [2]. Hormozgan is climatically apt to produce the date cultivar 'Piarom'. Cultivation of this variety has recently increased due to its desirable properties and high commercial value.

Date palms, like other plants, need to be supplied with balanced ratios of nutrients to reach optimum growth and fruit quality [3], [4]. Iron deficiency and its low mobility within the plant may prevent chlorophyll synthesis and cause chlorosis [5], [6]. Iron deficiency can also result in a decrease in assimilation rate, thus causing a decline in yield [7], [8].

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Some reports indicated that trunk injection of iron into the date palm trunk led to a considerable yield enhancement [9], [10]. Other researchers also showed that injection of $FeSO_4$ solution into the trunk caused a marked increase in iron content in leaves [11]-[13]. Other iron fertilization methods were also found to be effective on mitigating iron chlorosis in fruit trees [13], [14].

There are a lot of reports comparing the yield and chemical composition of date palm leaves treated with different iron fertilization methods. However, a comparison between trunk injection and other iron fertilization methods from the point of view of physicochemical changes in date fruits has not been done yet. Thus, the present research was done on Piarom palm trees to compare the effects of different methods and levels of iron fertilization on the yield and some fruit quality parameters such as moisture content, Brix index, reducing sugars, iron and potassium concentration.

II. Materials and Methods

This study was accomplished on 12-year-old date palms variety 'Piarom' in a calcareous soil of Hormozgan province in Iran, during four years. The experiment was performed on 54 trees as a randomized complete blocks design with nine treatments replicated three times. There were two trees in each treatment.

The treatments comprising three fertilization methods were exerted as follows:

- T1: control
- T2: soil surface placement of 100g Fe-EDDHA tree^{-1}, as a strip around the trunk
- T3: soil surface placement of 200g Fe-EDDHA tree^{-1}, as a strip around the trunk
- T4: deep placement of 1kg $FeSO_4$ tree^{-1}, incorporated with the soil (Chalkood method)
- T5: deep placement of 2kg $FeSO_4$ tree^{-1}, incorporated with the soil (Chalkood method)
- T6: trunk injection of a solution with zero concentration of Fe and a pH of 3.5
- T7: trunk injection of 25g $FeSO_4$ tree^{-1}, as a solution with a pH of 3.5
- T8: trunk injection of 50g $FeSO_4$ tree^{-1}, as a solution with a pH of 3.5

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- T9: trunk injection of 100g $FeSO_4$ $tree^{-1}$, as a solution with a pH of 3.5

According to the soil analysis results, all trees were uniformly supplied with corresponding amounts of nutrients as follows: 2kg ammonium sulfate, 1kg sulfur powder, 1kg triple super phosphate, 1kg potassium sulfate, 50gr Zn-EDTA and 70gr Mn-EDTA. Pollination was done with fresh pollens, regarding the custom of the region. All tress were irrigated through drip irrigation system. Fruit thinning was carried out with extra clusters deletion, considering the ratio of 8 leaves to 1 cluster in the kimri stage (when fruits become hard in texture and bright green in color, having moisture content of about 84 to 85.5%). Fruits were harvested and weighted each year in October, the second half. Brix index, as well as the concentrations of iron reducing sugars was determined in the fruits.

Obtained raw data were statistically analyzed and means comparison was accomplished using Duncan's multiple range test via MSTATC software. Figures were also prepared in Microsoft-Excel software.

III. Results and Discussion

This experiment was carried out during four years, but there was no significant difference between studied parameters in different years. Therefore, the results were reported as average values.

The highest yield was observed in the tress Injected with an acidic solution containing 25g $FeSO_4$ (T7). The next place was held by T8 and T9, whereas T6 caused the least yield level. Moreover, there was no statistical difference between T6 and T1 to T5 (Fig. 1). Therefore, trunk injection of iron fertilizer appeared to be more efficient than soil application. Despite the large amounts of total iron in most calcareous soils, the plant availability of this nutrient is usually very low, due to the effect of high pH on the formation of insoluble iron compounds in soil [15]. Trunk injection supplies the element directly to the respective tissues and therefore helps the plant to overcome the nutritional challenges caused by soil alkalinity. Enhancing availability of iron to plant results in an increase in photosynthesis and carbohydrate transportation in plant tissues, thereby increasing yield level [16]. Considerable yield enhancement with trunk injection of iron compounds was also reported by other researchers [6], [9], [13].

According to the Fig. 2, trunk injection of 100g $FeSO_4$ (T9) resulted in the highest iron content of fruits, showing no significant difference with T8 and T7 treatments. Injection of a solution with zero concentration of Fe and a pH of 3.5 (T6) also caused higher iron content than other non-injection treatments. This could be due to the cell sap acidification that makes iron more available to plant. Among the rest of treatments, trees supplied with $FeSO_4$ incorporated with subsoil (T4 and T5) showed more fruit iron content than those of treated with Fe-EDDHA incorporated with topsoil (T2 and T3). On the whole, T7, that is trunk injection of 25g $FeSO_4$, appeared to be the best treatment to increase fruit Fe content of 'Piarom' date-palm. Injection into the trunk may convey adequate iron to the plant, regardless of high pH of a calcareous soil [5]. The considerable effects of iron trunk injection on increasing iron uptake and transportation in date palm have been found by others [9], [12], [17]. Meanwhile, there are some other reports that confirm enhancing Fe concentration of fruit trees as a result of deep placement of iron fertilizers in the soil [7], [18].

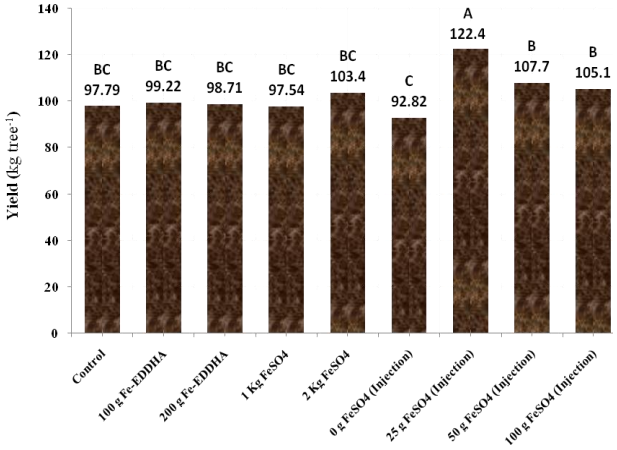

Figure 1. Fruit yield as affected by different treatments

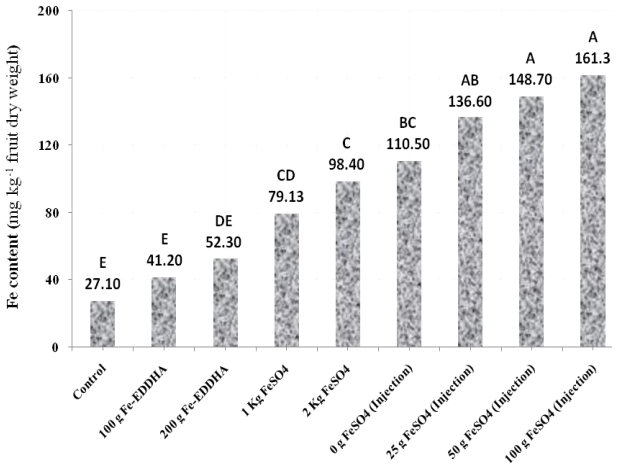

Figure 2. Fruit Fe content as affected by different treatments

Reducing sugars content showed no marked increase in treatments T2 and T3, compared with control. On the other hand, incorporation of $FeSO_4$ with subsoil (T4 and T5) resulted in a significant enhancement in fruit sugar percentage. The highest concentrations of reducing sugars in fruits were observed in trees subjected to trunk injection of $FeSO_4$ solution, recording the maximum concentration in the treatment T7 (Fig. 3). Sugars are the main products of photosynthesis and we know that iron is one of the plant micronutrients that plays an important role in photosynthesis in plants [19]-[21]. Trunk injection of an acidic solution of $FeSO_4$, not only supplies adequate iron for photosynthesis, but also may improve availability and translocation of other nutrients such as Zinc, Manganese and phosphorus by diminution of the plant sap pH [22]. Therefore, it seems reasonable that

trunk injection works better than other methods in calcareous soils. The effect of iron trunk injection on increasing reducing sugars content in date palm was also observed in other experiments [4], [13].

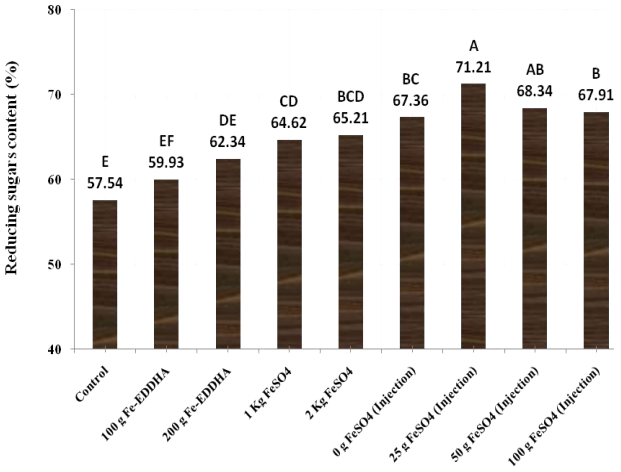

Figure 3. Reducing sugars content as affected by different treatments

TSS (Total Soluble Solids) is defined as the sum of the solids which are in a solution. In the present study we studied the effects of different iron fertilization methods on fruit total soluble solids. Results showed that the highest TSS values were obtained as a result of $FeSO_4$ trunk injection (Fig. 4). All $FeSO_4$ injection levels (T7, T8 and T9) were statistically the same and thus, T7 can be recommended as the best treatment. Fig. 4 also shows that deep placement of $FeSO_4$ is more efficient than Fe-EDDHA surface application. As it was said before, TSS is the sum of the solids including sugars, acids and minerals. Therefore, increasing uptake of nutrients in fertilized could improve synthesis of carbohydrates and acids, leading to accumulation of these soluble solids in fruits and raising TSS (Sanadgol, 1991; Carpenter, 1981). These results are in accordance with others' findings [4], [13], [23].

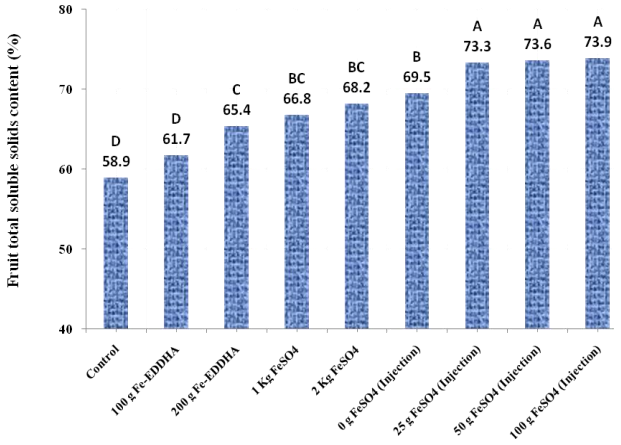

Figure 4. Fruit TSS as affected by different treatments

IV. Conclusions

Statistical analysis and interpretation of obtained data revealed that trunk injection of 25g $FeSO_4$ $tree^{-1}$ resulted in the highest increase in yield and improvement of fruit quality. However, in some cases, injection of 50 and 100 g $FeSO_4$ $tree^{-1}$ also caused statistically the same results. The next place belonged to deep placement of $FeSO_4$ (Chalkood method), whereas surface application of Fe-EDDHA had no marked difference with control. It is necessary to express that injection of solution with a zero concentration of $FeSO_4$ was often similar to control treatment, statistically. On the whole, treatment T7, that is trunk injection of 25 g $FeSO_4$ $tree^{-1}$ can be highly recommended as the best level and method for iron fertilization of date palm trees grown in calcareous soils.

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