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# EVALUATION OF SOME METHODS OF IRON AND BORON APPLICATION ON PRODUCTIVITY AND FRUIT QUALITY OF DATE PALM CV SAMANY

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**ABSTRACT:** This experiment was conducted during 2014 and 2015 seasons in a Private Orchard at Hirriyat Resznah Village, Sharkia Governorate, Egypt, to study the effect of different methods of fertilization with some minor elements (iron –Fe and boron –B) namely foliar application, trunk injection and soil application on yield and fruit quality of Samany date palm grown in clay soil under flood irrigation. Results indicated that date palm injection stem with Fe+B recorded the highest values of yield/palm, bunch weight, number of fruits/strand, average fruit weight, TSS, total and non reducing sugars and Vit. C content. The application of Fe + B in leaves axiles with abaxial bunch increased N, P contents and total protein in mature fruits in both seasons. Fe and B concentrations in fruits and pinnaes were the highest with the trees which sprayed Fe+B on bunch. Soil application with Fe+B was the superior treatment in increasing the contents of N, P, K and the concentration of Fe and B in roots of palm than other application method treatments. On the other hand, control treatment (untreated palms) recorded the highest values of total tannins in fruits and lowest values of all above-mentioned traits in both seasons.

**Key words:** Date palm, Samany, micronutrients, application methods, trunk injection.

## INTRODUCTION

Date palm (*Phoenix dactylifera* L.) is one of the oldest fruit trees in the world. It is known as "tree of life" because of its resilience, its need for limited water inputs, its long term productivity and its multiple purpose qualities. In Egypt, dates are important traditional crops. According to FAO (2013), Egypt is considered as the first country of the top ten date producers (1, 130, 000 tones).

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. As such fertilization with micronutrients as Fe and B are essential for producing healthy date palm as well as improving physical and chemical parameters of fruits.

Micronutrients are required in very small quantities (a few mg/kg) of plant tissues. Micronutrients play important roles in plant nutrition and crop production. Most of micronutrients participate in the functioning of a number of enzyme systems. There are considerable variation in the specific functions of the various micronutrients in plant processes. Zia *et al.* (2006) found a widespread deficiency of zinc, boron, followed by iron throughout the country due to nutrient fixation in the soil and restricted mobility of iron, zinc and boron in plant tissues.

Micronutrients deficiencies are more frequent in many soil types; *i.e.,* alkaline, calcareous and sandy soils (Srivastava and Gupta, 1996), moreover, the availability and uptake by plants of Fe and B decreases with increasing soil pH (Mortvedt *et al*., 1991). The mobility of microelements in soil, plant and their

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translocation to plants as well as interaction among them selves or with macroelements in the soil and plant play an important role in plants nutrition (Marschner, 1995).

Foliar sprays are widely used to apply micronutrients, especially iron and boron for many crops. Soluble inorganic salts generally are as effective as synthetic chelates in foliar sprays, so the inorganic salts usually are chosen because of their lower costs. Suspected micronutrient deficiencies may be diagnosed with foliar spray trials with one or more micronutrients. Also, advantages of foliar sprays are: (1) application rates are much lower than for soil application; (2) a uniform application is easily obtained; and (3) response to the applied nutrient is almost immediate so deficiencies can be corrected during the growing season (Mortvedt *et al*., 1991).

Trunk injection is a method of fertilizing trees through xylem tissue. This method was used along the time in small scale studies to solve the problem of uptake and /or translocation of a single element like iron or potassium the previous studies on efficiency ratio of soil fertilization proved that a small portion of the added fertilizers is taken up by the plant roots, while the great portion 62-85% of nitrogen (Dixon, 2003), 80-95% of P and K is lost by volatilization and fixation. So, injecting fertilizers directly through tree trunks may realize the efficacy of this method (Shaaban, 2012). Trunk injection is one of the efficient methods of fertilizers application. Iron deficiency chlorosis is a worldwide problem in crop production in calcareous soils (Mengel *et al*., 2001).

Iron is essential for the activity of several enzymatic systems and plant components such as catalase, cytochrome, frodoxin, frichrome, hematin, hem and cytochrome oxidase. In addition, it seems that iron is involved in nucleic acids metabolism in chloroplast. Usually relation between iron and vegetative growth of fruit trees is more complex than other nutrient elements (Saatsi and Yamur, 2000).

In this concern, injection Fe to date palm increased yield, fresh weight, fruit weight, fruit size, chemical characteristics and Fe in leaves than untreated or soil application treatment (Abo-Rady *et al*., 1987; Saleh, 2008; Abdi and Hedayat, 2010; Mohebi *et al.*, 2010). Such results were also found with Shaaban (2009) on mango and Fikry *et al.* (2016) on orange they found that trunk injected trees produced comparable higher yield of fruits with higher firmness, juice volume, TSS/acid ratio and Vit. C content.

Boron has an effect on cell wall structure and also has a major effect on cell elongation, root growth, fruit growth and development period and consequently fruit growth improves and transfer of sugar (Abdollahi *et al*., 2010).

The objective of this study is to investigate the effect of application methods of Fe and B fertilizers to recognize the best methods for increasing the productivity and fruit quality of Samany date palm grown in clay soil under flood irrigation system.

## MATERIALS AND METHODS

This experiment was conducted during 2014 and 2015 seasons at a Private Orchard in Hirriyat Resznah Village, Sharkia Governorate, Egypt, to study the effect of different fertilization methods by some minor elements of iron and boron compounds on yield and fruit quality of Samany date palm trees growing in clay soil under flood irrigation.

Soil samples were taken to determine the properties of experimental soil at two depths from soil surface, 0 to 60 cm and 60 to 120 cm. Such samples in each category were completely mixed and subjected to mechanical and chemical analyses to measure certain properties of soil according to Chapman and Pratt (1982). Chemical properties of the experimental orchard soil at different depths are presented in Table 1a.

Female palms 20- years-old with similar vigor, height and pollinated from one source male and subjected to the normal cultural practices applied for date palms in that district. The trees were planted at 7×7m under flood irrigation system. Five treatments were arranged in a completely randomized design with three replicates and two palms /each replicate, *i.e.,* the experimental comprised 5×3×2 =30 palms.

The treatments were as follows:

$T_1$- Control treatment (without Fe and B application).

$T_2$- Spraying of bunches by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).

**Table 1a. Chemical analysis of experimental soil**

| Depth (cm) | Chemical analysis | | | Macro nutrient (ppm) | | | Micro nutrient (ppm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | E.C. (ds/m) | pH | $CaCO_3$ (%) | N | P | K | Fe | Mn | Zn | Cu | B |
| **0-60** | 1.17 | 7.8 | 1.26 | 25 | 2.5 | 116 | 0.014 | 0.004 | 0.062 | 0.014 | 0.031 |
| **60-120** | 0.45 | 7.95 | 0.85 | 25 | 1.75 | 157 | 0.018 | 0.003 | 0.004 | 0.021 | 0.034 |

| Depth (cm) | Cation (meq/l) | | | | Anion (meq/l) | | | |
|---|---|---|---|---|---|---|---|---|
| | $K^+$ | $Na^+$ | $Mg^{++}$ | $Ca^{++}$ | $SO_4^{--}$ | $Cl^-$ | $HCO_3^-$ | $CO_3^-$ |
| **0-60** | 0.029 | 11.16 | 0.075 | 0.25 | 11.53 | 0.1 | 0.15 | - |
| **60-120** | 0.4 | 3.98 | 0.15 | 0.05 | 4.38 | 0.075 | 0.125 | - |

**Table 1b. Chemical analysis of the irrigation water**

| pH | EC Mmhos/$cm^3$ | $CaCO_3$ (%) | Cation (meq/100$cm^3$) | | | | Anion (meq/100$cm^3$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $Ca^{++}$ | $Mg^{++}$ | $Na^+$ | $K^+$ | $SO_4$ | $Cl^-$ | $HCO_3^-$ | $CO_3^-$ |
| 6.64 | 0.381 | 0 | 0.075 | .025 | 3.38 | .33 | 3.61 | 0.075 | 0.125 | ---- |

$T_3$- Spraying leaves axiles with abaxial bunch by Fe (60g $FeSo_4$ 20%) and boric acid (15g $H_3BO_3$).

$T_4$- Trunk injection by .Fe (60g $FeSo_4$ 20%) and boric acid (15g $H_3BO_3$) at 1.5 m above soil surface.

$T_5$- Soil application of Fe (200g EDDHA 6%) and boric acid (15g $H_3BO_3$).

The following four fertilization treatments and control are shown in Schedule 1.

These treatments were applied at two equal doses in each season, the first dose was after one week of pollination and the second was after 90 days from pollination (at El-khalal stage pre fruit color) in both seasons.

Solutions of above concentration of Fe and B fertilizer were prepared with distilled water. For trunk injection each tree was drilled with a hand drill 1.5m height from the soil surface and 30 cm depth in the trunk with 45 degree angel to down. These holes were carried out according to the traditional schedule (Abdi and Hedayat (2010) in date palm orchard. The leaf/bunch ratio was adjusted by the end of the blooming season to meat the value of 7:1 for all experimental palms during the two seasons of study.

Farmyard manure and phosphorus fertilizer were added in two exchangeable hollow, 1 m apart from palm trunk on Dec. in both seasons at the rate of 20 kg cattle manure and 2 kg Superphosphate calcium (15.5% $P_2O_5$). Nitrogen was added as ammonium sulphate (20.6% N) with rate of 1.5 Kg N/palm three times with beginning March at two month intervals in each season. Potassium was added as potassium sulphate (48% $K_2O$) at a rate of 2 Kg for each palm two times on March and July in each season.

Date palm trees were pollinated on March $10^{th}$ and $25^{th}$ in the $1^{st}$ and $2^{nd}$ seasons, respectively, by placing six fresh male strands on each female spadix (flower cluster) center.

The effect of the tested treatments on Samany palm trees and fruits was determined through the following parameters:

**Schedule 1. Fertilization treatments and control**

| Treatment | Iron | | Boron | |
|---|---|---|---|---|
| | Actual Fe (g/palm) | Fe | Actual B (g/palm) | B |
| $T_1$ | 0.0 | - | 0.0 | - |
| $T_2$ | 60 | Fe $SO_4$ 20% | 15 | $H_3BO_3$ |
| $T_3$ | 60 | Fe $SO_4$ 20% | 15 | $H_3BO_3$ |
| $T_4$ | 60 | Fe $SO_4$ 20% | 15 | $H_3BO_3$ |
| $T_5$ | 200 | EDDHA 6% | 15 | $H_3BO_3$ |

## Yield and Bunch Characteristics

At the normal date of commercial harvest time, bunches of each palm were picked out on first of October throughout the two experimental seasons.

Yield of each palm replicate was recorded in kilograms after harvest time. Number of bunches per palm and bunch weight (kg) were recorded and average number of fruits/strand were recorded at harvest.

$$\text{Relative yield (\%)} = \frac{\text{Yield of treatment - Yield of control}}{\text{Yield of control}} \times 100$$

## Fruit Characteristics

A sample of twenty five fruits for each replicate were washed with tap water at Khalal stages and the following data were recorded: average fresh weight (g), dry weight of fruit, fruit length (L) and diameter D (cm), fruit shape index (L/D), flesh weight (g), flesh fruit ratio and flesh (pulp) thickness (cm).

## Fruit Chemical Constituents

The chemical constituents of fruit samples at fresh stage were determined as follows:

**Total soluble solid (TSS%)**

It was determined in fruit juice by using carl-zeiss hand refractometer.

**Total acidity content (%)**

It was determined by titrating 5 ml from the juice sample with 0.1 N sodium hydroxide (NaOH), using phenolphthalein as an indicator. The acidity was expressed as gram of malic acid in 100 ml juice according to AOAC (1995).

**TSS/acid ratio**

It was calculated by dividing TSS values on total acidity of fruit juice.

**Sugar percentage**

Total, reducing and non reducing sugars were determined according to Smith *et al*. (1956).

**Total protein**

It was calculated by multiplying total nitrogen × 6.25.

**Tannins and Vit. C mg/100 ml juice**

Tannins and Vit. C were determined according to AOAC (1995).

**Leaf pigments**

Disc samples from the pinnae of palm leaves were randomly taken at the middle 1- year - old leaves from every tree on March from the start of treatments in both seasons to determine chlorophyll a and b and carotenoides according to the method described by Wettestein (1957).

**Nitrogen, phosphorus and potassium contents**

Nitrogen, phosphorus and potassium contents in roots, pinnae and fruit were determined according to the methods described by Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Jackson (1970), respectively

**Iron and boron contents**

Iron and boron in roots, pinnae and fruit samples in both seasons were determined using

Atomic-absorption (Analyst 200, Perkin Elmer, Inc., MA, USA), according to the methods described by Chapman and Pratt (1982).

### Statistical Analysis

The recorded data were subjected to the statistical analysis of variance according to Snedecor and Cochran (1980), and means separation were done according to Duncan (1955) at 0.05 levels of probability.

## RESULTS AND DISCUSSION

### Yield and its Components

Results in Table 2 show significant differences among all application methods of Fe and B concerning the yield and its components of date palm cv. Samany in both seasons.

The values of yield/palm ranged from 286.25 to 326.54 kg and 282.42 to 328.12 kg, while the bunch weight ranged from 47.70 to 54.42 and 57.07 to 54.68 kg/bunch in the 1st and 2nd seasons, respectively.

In general, treated date palm trees with Fe+B through $T_4$ (trunk injection) recorded the highest values of yield/palm (326.54 and 328.12 kg), bunch weight (54.42 and 54.68 kg), number of fruits/strand (16.33 and 15.49 fruits/ strand), fruit fresh weight (35.86 and 37.11 g) and dry weight of a fruit (14.69 and 15.01 g) in the 1st and 2nd seasons, respectively. Meanwhile control treatment recorded the lowest values of all yield and its components in both seasons.

The relative increases in total yield/palm due to $T_4$ (injection of iron and boron into date palm trunk) were about 14.08 and 16.18%, followed by $T_5$ (treated date palm with Fe+B as soil application) 9.81 and 9.26% over the control treatment in the 1st and 2nd seasons respectively.

As for fruit dimensions and fruit shape index, in general the best treatment was the injection by Fe+B ($T_4$) in both seasons. As for fruit shape index, the highest values were $T_3$ in both seasons. While the lowest values were recorded with the control ($T_1$) in both seasons.

Regarding fruit characteristics, the data reveal that fresh weight, and flesh thickness were significantly affected by application methods, except pulp/ fruit ratio in the 1st season, whereas injection application method was the superior treatment in both seasons. The highest flesh thickness was obtained when trees were treated with $T_4$, that was adopted in both season. On the other hand, the lowest values of fresh weight of Samany fruits, flesh/fruit ratio and flesh thickness were obtained by using $T_1$ (control) treatment in both seasons.

Generally, it can be concluded that, injection of Fe and B in trunk was the best treatment for enhancing yield and its components, followed by spraying bunch /or soil application.

The increase in size of fruit as a result of foliar application of micronutrients in present investigation might be because it improved the internal physiology of developing fruit in terms of better supply of water, nutrients, and other compounds vital for their proper growth and development (Dutta and Banik, 2007 on guava trees).

Trunk injections with soluble nutrients are often employed to alleviate deficiencies of Fe in trees with impaired root systems or those growing in calcareous soils. Also, trunk injections are therefore normally reserved for treatment or prevention of lethal diseases or disorders where soil or foliar applications are ineffective or impractical (Timothy and Doccola, 2010).

Boron is an essential element for plants. It has significant roles in different metabolic functions that may impact tree yield (Marschner, 1995). A spray application of B to the leaves is more effective and economical in comparison with a soil application (Perica *et al*., 2002 on olive). Foliar fertilization can influence nutritive competition between different metabolic sinks and control the growth and reproductive activities of fruit trees (Wojcik, 2004).

The obtained results are in agreement with those reported by Saleh (2008), Abdi and Hedayat (2010), Gholamereza and Hedayat (2010), Mohebi *et al.* (2010), Elsabagh (2012), Sarrwy *et al.* (2012), Omar *et al.* (2014), Mosa *et al.* (2015) on date palms and Fikry *et al*. (2016) on orange. They found that trees treated with Fe or B by injection or foliar spray method increased yield and its components as fruit physical properties, *i.e.,* fruit length and diameter than untreated trees.

**Table 2. Effect of application method of iron and boron on yield and its components of Samany date palm during 2014 and 2015 seasons**

| Treatment | Yield/ palm (kg) | Bunch weight (kg) | No. of fruits/ strand | Fruit fresh weight (g) | Fruit dry weight | Relative increases in yield/palm | Fruit length (cm) | Fruit diameter (cm) | Fruit shape index | Flesh weight (g) | flesh / fruit ratio | Flesh thickness (cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **First season 2014** | | | | | | |
| $T_1$ | 286.25 e | 47.70 c | 14.13 b | 34.16 c | 12.97 c | 0.00 | 5.23 b | 3.50 d | 1.50 a | 31.15 b | 0.91 a | 0.96 d |
| $T_2$ | 309.84c | 51.64 b | 15.76 a | 34.80 bc | 14.58 a | 8.24 | 5.49 a | 3.61 cd | 1.51 a | 31.67 b | 0.91 a | 1.06 b |
| $T_3$ | 293.54d | 48.92 c | 15.72 a | 35.50 ab | 14.18 b | 2.55 | 5.62 a | 3.70 bc | 1.51 a | 32.85 a | 0.91 a | 1.03 c |
| $T_4$ | 326.54 a | 54.42 a | 16.33 a | 35.86 a | 14.69 a | 14.08 | 5.71 a | 3.88 a | 1.47 a | 32.60 a | 0.92 a | 1.08 a |
| $T_5$ | 314.33 b | 52.38 b | 15.70 a | 35.83 a | 14.47 ab | 9.81 | 5.59 a | 3.80 ab | 1.47 a | 32.98 a | 0.91 a | 1.02 c |
| | | | | | | **Second season 2015** | | | | | | |
| $T_1$ | 282.42 e | 47.07 e | 14.30 b | 34.84 c | 14.59 bc | 0.00 | 5.10 d | 3.61 d | 1.41 c | 31.76 c | 0.91ab | 0.98 d |
| $T_2$ | 315.66 b | 52.61 b | 15.45a | 36.00 b | 14.90 ab | 11.77 | 5.66 c | 3.87 b | 1.46 bc | 33.02 b | 0.92 a | 1.01 c |
| $T_3$ | 305.16 d | 50.17 d | 15.20 a | 35.33 c | 14.49 c | 8.05 | 5.86 ab | 3.72 c | 1.57 a | 32.13 c | 0.90 b | 1.03 c |
| $T_4$ | 328.12 a | 54.68 a | 15.49 a | 37.11 a | 15.01 a | 16.18 | 5.93 a | 3.96 a | 1.49 b | 34.12 a | 0.92 a | 1.22 a |
| $T_5$ | 308.58 c | 51.43 c | 15.37 a | 35.37 bc | 14.78a-c | 9.26 | 5.83 b | 3.86 b | 1.51 b | 32.31 c | 0.91ab | 1.13 b |

$T_1$: Control treatment (without Fe and B).
$T_2$: Bunch spray by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_3$: Spraying of fruiting leaves axilla by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_4$: Trunk injection by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$)
$T_5$: Soil surface application of Fe (200g EDDHA 6%) and boric acid (15g $H_3BO_3$).
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of the probability, according to Duncan's multiple range test.

## Fruit Quality

Results regarding TSS, acidity and TSS/ acid ratio in fruits are shown in Table 2. It is obvious from such results that TSS, acidity and TSS/ acid ratio were significantly affected by Fe+B application methods. The results reveal that different application methods increased the previous parameters which were significantly affected compared to control, except total acidity. Application of Fe+B as injection into trunk was the best treatment which recorded the highest values of TSS compared to the other application methods and check treatment. Regarding TSS acid ratio, $T_4$ significantly increased TSS/ acid ratio with significant differences with TS in the 1st season and $T_3$ in the 2nd season. While untreated palms recorded the lowest values of TSS and highest values of total acidity in both seasons.

Table 3 illustrate the effect of Fe+B application methods on reducing, non reducing and total sugars in date fruit in both seasons. The values of total sugars ranged from 20.76 to 28.05% and 21.76 to 29.32% in the 1st and 2nd seasons, respectively. Total and non reducing sugars in fruits increased with injection methods ($T_4$) than soil application ($T_5$) or untreated palms ($T_1$). While $T_2$ increased reducing sugars in fruits. On the contrary, untreated palms treatment $T_1$ gave the lowest values in this respect.

Regarding total protein, tannins and Vit.C in fruits, the results in Table 3 show that total protein, tannins and Vit.C in fruits were significantly affected by the tested treatments in both seasons.

Results also revealed that application of Fe+B as spray of leaves axilla ($T_3$) increased total protein in fruits (10.44 and 8.00%) in the two seasons. While control treatment recorded the lowest values of total protein (8.52 and 6.69%) and Vit C and highest values of total tannins in fruits (0.180 and 0.177% in the 1st and 2nd seasons, respectively). Fe+B as solution injection into trunk (T4) gave the highest values of Vit. C (2.90 and 3.90 mg/100 ml juice in 1st and 2nd seasons).

**Table 3. Effect of application method of iron and boron on fruit quality of Samany date palm during 2014 and 2015 seasons**

| Treatment | TSS (%) | Acidity (%) | TSS/acid ratio | Reducing sugars (%) | Non reducing sugars (%) | Total sugars (%) | Total protein (%) | Tannins (%) | Vit. C (mg/100 ml juice) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **First season 2014** | | | | |
| $T_1$ | 28.00 c | 0.140 a | 200.00 c | 16.06 c | 4.70 b | 20.76 b | 8.52e | 0. 180 a | 1.00 d |
| $T_2$ | 30.00 b | 0.123 bc | 243.40 b | 19.13 a | 8.69 a | 27.82 a | 8.75 c | 0. 170 b | 1.30 c |
| $T_3$ | 29.50 b | 0.126 b | 233.27 b | 17.20 b | 9.76 a | 26.96 a | 10.44a | 0. 153 c | 1.70 b |
| $T_4$ | 31.50 a | 0.113 c | 280.00 a | 16.80 bc | 11.25a | 28.05 a | 8.63d | 0. 140 d | 2.90 a |
| $T_5$ | 30.02 b | 0.100 d | 300.20 a | 18.64 a | 4.59 b | 23.23 b | 9.21b | 0. 140 d | 1.20 c |
| | | | | | **Second season 2015** | | | | |
| $T_1$ | 28.09 e | 0.153 a | 183.37 d | 17.63 bc | 4.13 c | 21.76 b | 6.69c | 0.177 a | 1.00 e |
| $T_2$ | 30.58 c | 0.146 ab | 209.30 c | 18.23 ab | 9.78 a | 28.01 a | 7.69b | 0.173 a | 1.60 d |
| $T_3$ | 29.61d | 0.126 d | 234.10 ab | 16.58 c | 7.20 b | 23.78 b | 8.00a | 0.140 b | 1.80 c |
| $T_4$ | 31.50 a | 0.130 cd | 242.30 a | 17.46 bc | 11.86 a | 29.32 a | 7.63b | 0.137 b | 3.90 a |
| $T_5$ | 30.86 b | 0.140 bc | 220.43 bc | 19.31 a | 5.32 bc | 24.63 b | 7.50b | 0.140 b | 2.90 b |

$T_1$: Control treatment (without Fe and B).
$T_2$: Bunch spray by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_3$: Spraying of fruiting leaves axilla by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_4$: Trunk injection of tree by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$)
$T_5$: Soil surface application of Fe(200g EDDHA 6%) and boric acid (15g $H_3BO_3$).
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of the probability, according to Duncan's multiple range test.

Soil applications are not very effective because the roots of fruit crops occupy deep soil layers and both Fe and B does not easily translocate in the soil, therefore, foliar sprays are more effective (Chandler *et al*., 1931). Micro-nutrients such as iron and boron are essential for different biological functions that might be attributed to fruit quality (Shoeib and El-Sayed 2003). A favorable effect of foliar application of boron might be due to its role in cell division, cell elongation, sugar metabolism and accumulation of carbohydrates (Sourour, 2000).

The increment of TSS with B application may be due to that boron helps in translocation of sugarborate complex (Srivastava and Gupta, 1996).

The obtained results are generally in harmony with those reported by Desouky *et al*. (2007), Saleh (2008), Abdi and Hedayat (2010), Gholamereza and Hedayat (2010), El-Assar and El-Sehrawy (2011) Sarrwy *et al.* (2012) and Omar *et al.* (2014) on date palm. They found that nutrients spraying or trees injection increased TSS, TSS/acid ratio, total sugars and vitamin C in fruit than untreated trees.

**Fruit chemical constituents**

The results revealed that the application of Fe+B through the tested application methods had significant effect on N, P, K, Fe and B contents in fruits of Samany date palm in both seasons (Table 4). N, P and K contents in fruits increased with sprayed trees with Fe+B on leaves axilla ($T_3$) (1.67 and 1.28 N%), (0.258 and 0.240% P) in the 1st and 2nd seasons, respectively, while control treatment ($T_1$) recorded the lowest values in this respect (1.36 and 1.07 N%), (0.076 and 0.200 %P) and (1.20 and 1.22 K%) in the 1st and 2nd seasons, respectively. Concerning Fe and B concentrations in fruits, results in Table 4 reveal that bunch spray ($T_2$) was the best treatment as it increased Fe and B in fruits (22.0 and 28.0 ppm Fe) and (4.50 and 4.90 ppm B) in the 1st and 2nd seasons , respectively. On other hand , control

**Table 4. Effect of application method of iron and boron on fruit mineral contents of Samany date palm during 2014 and 2015 seasons**

| Treatment | Fruit mineral content | | | | |
|---|---|---|---|---|---|
| | N (%) | P (%) | K (%) | Fe (ppm) | B (ppm) |
| | | | **First season 2014** | | |
| $T_1$ | 1.36 e | 0.076 b | 1.20 c | 4.00 d | 2.50 e |
| $T_2$ | 1.40 c | 0.210 a | 1.30 a | 22.00 a | 4.50 a |
| $T_3$ | 1.67 a | 0.258 a | 1.25 b | 18.00 b | 3.30 c |
| $T_4$ | 1.38 d | 0.231 a | 1.29a | 19.33 b | 4.10 b |
| $T_5$ | 1.47 b | 0.213 a | 1.20 c | 7.00 c | 2.90 d |
| | | | **Second season 2015** | | |
| $T_1$ | 1.07 c | 0.200 b | 1.22 b | 4.00 d | 2.60 d |
| $T_2$ | 1.23 b | 0.203 b | 1.21 b | 28.00 a | 4.90 a |
| $T_3$ | 1.28 a | 0.240 a | 1.30 a | 21.00 b | 4.30 b |
| $T_4$ | 1.22 b | 0.235 a | 1.30 a | 20.00 b | 3.60 c |
| $T_5$ | 1.20 b | 0.240 a | 1.20 c | 9.00 c | 3.00 d |

$T_1$: Control treatment (without Fe and B).
$T_2$: Bunch spray by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_3$: Spraying of fruiting leaves axilla by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_4$: Trunk injection of tree by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$)
$T_5$: Soil surface application of Fe (200g EDDHA 6%) and boric acid (15g $H_3BO_3$).
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of the probability, according to Duncan's multiple range test.

treatment ($T_1$) recorded the lowest values (4.0 and 4.0 ppm Fe) and (2.50 and 2.60 ppm B) in the 1st and 2nd seasons, respectively.

It could be concluded that treated date palm trees with Fe+B with any application methods such as bunch spray, spraying of fruiting leaves axilla and injection into the trunk of tree were the superior treatments for enhancing the contents of N, P, K, Fe and B in fruits than soil application

The above results are in agreement with those reported by Darwesh *et al*. (2015) on date palm cv. Sewii.

**Pinnaes chemical composition**

The results revealed that N, P, K, Fe and B contents in pinnaes were significantly affected by application methods compared to the control treatment in both seasons (Table 5). The highest value of nitrogen (2.60 and 2.51%) were recorded by T3 in the 1st season and T2 or T5 in the 2nd season, phosphorus (0.237 and 0.233%) with T2 and T5 in the 1st and 2nd seasons, respectively, K (1.90 and 1.20%), Fe (210.00 and 218.33 ppm) and B (36.0 and 38.0 ppm) with T2 in the 1st and 2nd seasons, respectively.

On the contrary, the lowest values were obtained by untreated treatment (2.32 and 2.41 N%), (0.200 and 0.201% P) and (1.23 and 1.10 K%), (70.0 and 90.0 ppm Fe) and (17.0 and 19.0 ppm B) in the 1st and 2nd seasons, respectively. It could be concluded that, using any foliar application methods of Fe + B to date palm, especially to bunch were the superior treatments as compared to soil application or untreated treatment regarding the contents of K, Fe and B in leaves.

**Photosynthetic pigments**

Data in Table 6 show the effect of the tested microelements (Fe+ B) application methods on photosynthetic pigments of date palm leaves during 2014 and 2015 seasons.

**Table 5. Effect of application method of iron and boron on pinna mineral contents of Samany date palm during 2014 and 2015 seasons**

| Treatment | Mineral contents in pinna | | | | |
|---|---|---|---|---|---|
| | N (%) | P (%) | K (%) | Fe (ppm) | B (ppm) |
| | | | First season 2014 | | |
| $T_1$ | 2.32 e | 0.200 b | 1.23 b | 70.00 e | 17.00 e |
| $T_2$ | 2.40 d | 0.237 a | 1.90 a | 210.00 a | 36.00 a |
| $T_3$ | 2.60 a | 0.213 a | 1.88 a | 130.00 c | 28.00 c |
| $T_4$ | 2.53 c | 0.232 a | 1.20 b | 90.00 d | 21.00 d |
| $T_5$ | 2.56 b | 0.221 a | 1.18 b | 150.00 b | 33.00 b |
| | | | Second season 2015 | | |
| $T_1$ | 2.41 b | 0.201b | 1.10 b | 90.00 c | 19.00 c |
| $T_2$ | 2.51 a | 0.212a | 1.20 a | 218.33 a | 38.00 a |
| $T_3$ | 2.32 c | 0.223 a | 1.21 a | 180.00 b | 34.00 a |
| $T_4$ | 2.41 b | 0.220a | 1.16ab | 100.00 c | 26.00 b |
| $T_5$ | 2.52 a | 0.233 a | 1.13 b | 180.00 b | 29.00 b |

$T_1$: Control treatment (without Fe and B).
$T_2$: Bunch spray by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_3$: Spraying of fruiting leaves axilla by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_4$: Trunk injection of tree by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$)
$T_5$: Soil surface application of Fe (200g EDDHA 6%) and boric acid (15g $H_3BO_3$).
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of the probability, according to Duncan's multiple range test.

**Table 6. Effect of application method of iron and boron on leaf pigments (mg/g fresh weight) of Samany date palm during 2014 and 2015 seasons**

| Treatment | Chl. a | Chl. b | Total chl. (a+b) | Carotenoides |
|---|---|---|---|---|
| | | First season 2014 | | |
| $T_1$ | 2.96c | 0.99e | 3.95c | 2.51c |
| $T_2$ | 4.84a | 1.88a | 6.72a | 3.53ab |
| $T_3$ | 4.76a | 1.73a | 6.50a | 4.05a |
| $T_4$ | 4.65a | 1.71a | 6.36a | 2.64bc |
| $T_5$ | 3.48b | 1.46c | 4.94b | 2.98bc |
| | | Second season 2015 | | |
| $T_1$ | 2.96c | 1.60b | 4.58c | 3.37d |
| $T_2$ | 5.90a | 2.33a | 8.23a | 5.09a |
| $T_3$ | 5.72a | 2.56a | 8.28a | 4.89ab |
| $T_4$ | 5.62a | 2.45a | 8.07a | 4.76b |
| $T_5$ | 4.20b | 1.46b | 5.65b | 3.60c |

$T_1$: Control treatment (without Fe and B).
$T_2$: Bunch spray by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_3$: Spraying of fruiting leaves axilla by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_4$: Trunk injection of tree by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$)
$T_5$: Soil surface application of Fe (200g EDDHA 6%) and boric acid (15g $H_3BO_3$).
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of the probability, according to Duncan's multiple range test.

The results indicate that leaf pigments contents were significantly affected by the tested treatments.

The results show that foliar application of Fe and B on bunch, leaves axilla or injection into trunk ($T_2$, $T_3$ or $T_4$) increased chlorophyll a (Chl.a), chlorophyll b (Chl. B), total chlorophyll (a + b) and carotenoids in date palm leaves in both seasons, without significant differences with soil application of Fe+B ($T_5$) regarding Chls. a, b and total Chl. (a+b) in the 2nd season only. While control treatment ($T_1$) recorded the lowest values in the above mentioned traits in both seasons.

It could be suggested that, photosynthetic pigments in date palm leaves (Chl. a, Chl. b, total Chl. a + b, and carotenoids) were significantly increased with application of Fe + B as spray on bunch, leaves axilla or injection into trunk in both seasons. These results agree with those reported by Saleh (2008) on palm.

**Root chemical composition**

Results revealed that the application methods of Fe+B had significant effect on N,P , K , Fe and B contents in roots of Samany date palm in both seasons (Table 7).

N, P and K percentages and the concentrations of Fe and B in roots were significantly increased with adding Fe+B as soil application (T5) in both seasons and recorded (1.56 and 1.23% N), (0.131 and 0.163% P), (1.20 and 1.21% K), (15.0 and 16.0 ppm Fe) and (1.55 and 1.85 ppm B) in the 1st and 2nd seasons, respectively, while control treatment (T1) recorded the lowest values in this respect (1.19 and 1.03% N), and (3.0 and 3.0 ppm Fe) and (0.60 and 0.60 ppm B) in the 1st and 2nd seasons, respectively.

**Table 7. Effect of application methods of iron and boron on root chemical composition of Samany date palm during 2014 and 2015 seasons**

| Treatments | N (%) | P (%) | K (%) | Fe (ppm) | B (ppm) |
|---|---|---|---|---|---|
| | | | **First season 2014** | | |
| **$T_1$** | 1.19 b | 0.113 c | 1.10 c | 3.00 d | 0.60 d |
| **$T_2$** | 1.18 b | 0.101 d | 1.09 d | 5.00 c | 0.85 c |
| **$T_3$** | 1.25 b | 0.118 b | 1.13 b | 10.00 b | 1.20 b |
| **$T_4$** | 1.23 b | 0.111 c | 1.02 e | 9.13 b | 1.50 a |
| **$T_5$** | 1.56 a | 0.131 a | 1.20 a | 15.00 a | 1.55 a |
| | | | Second season 2015 | | |
| **$T_1$** | 1.03 d | 0.135 c | 1.12 c | 3.00 d | 0.60 d |
| **$T_2$** | 1.00 e | 0.123 d | 1.14 b | 7.00 c | 0.96 c |
| **$T_3$** | 1.21 b | 0.155 b | 1.11 d | 14.00 b | 1.46 b |
| **$T_4$** | 1.10 c | 0.137 c | 1.06 e | 13.63 b | 1.56 b |
| **$T_5$** | 1.23 a | 0.163 a | 1.21 a | 16.00 a | 1.85 a |

$T_1$: Control treatment (without Fe and B).
$T_2$: Bunch spray by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_3$: Spraying of fruiting leaves axilla by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$).
$T_4$: Trunk injection of tree by Fe (60g $FeSO_4$ 20%) and boric acid (15g $H_3BO_3$)
$T_5$: Soil surface application of F e(200g EDDHA 6%) and boric acid (15g $H_3BO_3$).
Values having the same alphabetical letter(s) did not significantly differ at the 0.05 level of the probability, according to Duncan's multiple range test.

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# تقييـم بعض طـــرق إضـــافـة الحـديد والبـورون على إنتاجية وجودة الثمار في صنف البلح السمانى

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أجريت هذه الدراسة خلال موسمى ٢٠١٤ ، ٢٠١٥ على نخيل البلح صنف سمانى ببستان نخيل خاص بقرية هرية رزنة، الزقازيق ، محافظة الشرقية ، مصر، بهدف دراسة تأثير الطرق المختلفة لإضافة بعض العناصر الصغرى (الحديد والبورون) على النحو الآتى: الرش على السوباطة، الإضافة فى ابط الورقة المثمرة ، الحقن داخل جذع النخلة، الإضافة الأرضية، وعدم الإضافة (معاملة المقارنة) على المحصول وجودة ثمار نخيل البلح صنف السماني النامي في الأرض الطينية تحت نظام الرى بالغمر، وقد أوضحت النتائج أن حقن جذع نخيل البلح بالحديد والبورون قد سجل أعلى القيم لكل من محصول النخلة، وزن السوباطة، عدد الثمار/ الشمراخ، متوسط وزن الثمرة ، محتوى الثمار من المواد الصلبة الذائبة، والسكريات الكلية والمختزلة وغير المختزلة وفيتامين ج في طور البلح الخلال، أدت طريقة الإضافة للحديد والبورن فى ابط الورقة المثمرة إلى زيادة محتوى الثمار من النيتروجين والفوسفور والبروتين الكلى خلال الموسمين، وازداد تركيز كل من الحديد والبورن في الثمار بمعاملتي الرش للعنصرين على السوباطة، وحققت معاملة الإضافة الأرضية لعنصرى الحديد والبورون زيادة محتوى الجذور من النيتروجين والفوسفور والبوتاسيوم والحديد والبورون مقارنه بباقى المعاملات المختبرة الأخرى فى كلا الموسمين. على الجانب الأخر، فقد سجلت معاملة الكونترول (المقارنة) أعلى مستوى للتانينات فى الثمار واقل القيم لمعظم الصفات السابق دراستها خلال الموسمين.

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