Roots growth of apricot (*Prunus armeniaca* L.) as influenced by iron and copper foliar application

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**Abstract** This experiment was conducted in the plant canopy of the Department of Horticulture and landscape / College of Agriculture / University of Karbala for the period from mid-March to end of June 2019 to study the effect of spraying with different concentrations of iron and copper on the growth of apricot seedlings local variety. The experiment carried out using Randomized Complete Block Design (R.C.B.D) as a factorial experiment with two factors: iron with three concentrations 0, 30 and 60 mg. l⁻¹ and copper with three concentrations 0, 20 and 40 mg.l⁻¹ with three replicates for each treatment. Seedlings sprayed twice, duration from one spray to another one week starting from 15/3/2019. Irrigation done before spraying date for all treatments, at the end of June 2019, measurements taken and the results analyzed according to the statistical design used and the averages compared according to the least significant difference test with 0.05 probability. The most important results were:
- Treatment with an iron concentration of 60 mg. l⁻¹ was the highest rates significantly compared to other concentrations in all growth traits.
- Treatment achieved with copper at concentration of 40 mg.l⁻¹ significant superiority in most growth characteristics (root length, root size and dry weight of the root) , while 20 mg. l⁻¹ significantly superior in the root diameter.
- The interaction between two factors had a significant effect on the majority of growth traits (root length, root size and dry weight of the root) respectively, while the interaction did not have a significant effect on the character of the root diameter.

1. **Introduction**

Apricot belongs to the Rosaceae family (*Prunus armeniaca* L.) [1]. The apricot tree history back 5,000 years in China to the reign of Emperor Yu. [2] Other sources suggest that its native place is northern China. It was planted since 4,000 years ago [3] and there are wild species from Japan to Afghanistan and the Romans called the Armenian apple, and therefore some scientists believed that the origin of apricots from Armenian and so named by this name [3 ; 4]. The word apricot belongs to the Greeks, where it called AL-Praecox, which means early fruit [2]. Apricot fruit is an excellent source of sugars and contains a precious collection of minerals and vitamins, its effect is a moisturizer, stomach cooler, blood tonic, reduces thirst, breaks down gravel and repels worms [5 ; 6]. Fertilization is one of the most important factors affecting the growth of fruit trees in general. It
was necessary to use various means, including the process of foliar nutrition with microelements such as iron and copper. As known, the microelements subjected to sedimentation and the formation of a complex compound is not ready for absorption by the roots of plants, especially in the alkaline soils prevailing in central and southern Iraq. This reduces its readiness and hinders its absorption by the plant [7]. It is worth mentioning that iron has a role in the construction of chlorophyll. Although it does not enter into its structure but it enters the process of formation of RNA and thus helps to form proteins in cell walls [8] and there is 80% of the iron in chloroplasts [7] and iron deficiency causes direct effects on carbon metabolism resulting in reduced yields [9]. Copper also has an active role in the formation of chlorophyll and other colorants in plant tissue. A number of enzymes include Phenolase, laccase, ascorbic oxidase and cytochrome oxidase [10]. Noted that spraying the seedlings of Sidr var. tafahi with ferrous sulphate with concentrations of 200 mg.l⁻¹ significantly increased the length, diameter and the dry weight of the root compared with control treatment. [12] Found that the local orange seedlings grafted on the Sour orange of one year-old sprayed with ferrous sulphate with concentrated 0.5 and 1 g. l⁻¹. It resulted in a significant increase in root length and dry weight of the root compared with control treatment. [13] Found a significant increase in root length and dry weight of the root when spraying olive seedlings of a year-old Khastawi variety with chelated iron in concentrations of 50 and 100 mg.l⁻¹.

The research aimed to study the effect of spraying iron and copper in accelerating the growth of apricot seedlings and improve their root growth.

2. Materials and methods

The experiment was carried out in the canopy of the Department of Horticulture and landscape / College of Agriculture / University of Karbala for the period from mid-March to the end of June 2019 to study the effect of spraying with different concentrations of iron and copper in the growth of apricot seedlings local variety. Selected 54 seedlings and homogeneous as possible in size and growth of vegetation and growing in a mixture of sandy sand and planted in black plastic bags made of polyethylene material capacity of 1.25 kg and then converted on 3/3/2019 to bags with a capacity of 2 kg of soil as described in table 1.

Randomized Complete Block Design (R.C.B.D) designed as a factorial experiment with two factors: iron and copper, with three concentrations for each and three replicates, each containing 18 seedlings and 2 seedlings per treatment. Seedlings sprayed with a 1 liter hand spray and added with each concentration of 1 cm³ of the diffuser to reduce the surface tension of water molecules and for causing complete wetness of the vegetative parts. Seedlings were sprayed with Fe-EDTA (6% iron) early in the morning with three concentrations of 0, 30 and 60 mg.l⁻¹.

In the evening, the seedlings sprayed with copper in the form of CuSO₄.5H₂O (24.8% copper) in three concentrations 0, 20 and 40 mg.l⁻¹. The spraying done twice and the period from one to another was 7 days starting from 15/3/2019.

The control treatment spraying with distilled water only and spraying done after irrigation of the seedlings. One day before the spraying date in order to increase the plant's efficiency. In absorbing the sprinkler material because, the moisture is an important role in the process of swelling of guard cells and open stomata. As well as the fact that irrigation before spraying works to reduce the concentration of dissolved in leaf cells it increases the penetration of spray solution ions into leaf cells [10]. All irrigation and weeding (bagging) of bags or between replicates and all treatments carried out equally and measurements taken at the end of June 2019.

3. Studied traits:

3.1. Root length (cm)

The average length of the longest root (cm) seedlings removed from the planted bags. In addition, the vegetative total separated from the total root from the swollen crown area of apricot seedlings.
Moreover, the roots washed with water. The longest root then measured by a metric bar from the crown area near the soil surface to the end of the root.

3.2. Root volume average (cm$^3$)
The root total volume of seedlings measured using a known size cylinder.

3.3. Average root diameter (cm)
Calculated by equation [14].

3.4. Average dry weight of root total (gm)
After removal of seedlings from the transplanted bags.
The roots washed with water and placed in perforated paper bags in an electric oven at 70 °C until weight stabilized and weighed with a delicate electric balance.

At the end of the experiment, the data analyzed according to the design (R.C.B.D) with three replicates. The results were analyzed according to the design followed by as factor experiment with two factors (3 × 3) for iron and copper and the averages were compared according to the least significant difference test L.S.D at the probability level 0.05 [15].

| Soil characteristics | Sandy mixture     |
|----------------------|------------------|
| Soil texture         |                  |
| Sand                 | 871 gm.kg$^{-1}$ |
| Silt                 | 41 gm.kg$^{-1}$  |
| Clay                 | 88 gm.kg$^{-1}$  |
| pH                   | 7.8              |
| E.C                  | 1.25 decimens.m$^{-1}$ |
| N                    | 28.70 mg.kg$^{-1}$ |
| P                    | 0.46 mg.kg$^{-1}$ |
| K                    | 35.00 mg.kg$^{-1}$ |

4. Results and Discussion

4.1. Root length (cm)
The results shown in table 2 indicate a significant effect of iron spraying on the root length of seedlings. The iron spray treatment at a concentration of 60 mg.l$^{-1}$ gave the highest rate of 46.33 cm, Seedlings in the control treatment showed the lowest rate of 36.44 cm. This may be due to the effect of iron in the construction of chlorophyll, which increases the efficiency of carbon representation and then increases growth rates, especially as it helps to form cell walls and then increase the length of the root [10]. Copper spraying also had a significant effect on the rate of this trait it found that the highest rate of this characteristic in seedlings treated with copper at a concentration of 40 mg.l$^{-1}$ it is 43.33 cm, while the lowest rate was 39.67 cm in control treatment. This may be due to its effect on light reactions in the process of carbon metabolism and involved in the synthesis of a number of enzymes leading to improved growth indicators, including the length of the root of the plant [16].

The interaction also had a significant effect on the root length rate. As the seedlings gave iron treatment at 60 mg.l$^{-1}$ and copper at 40 mg.l$^{-1}$ the highest rate was 48.33 cm compared with the control treatment that gave the lowest rate of this characteristic was 35.33 cm, these results are consistent with what he found [11; 12; 13].
Table 2. Effect of iron and copper spraying and their interaction on the root length (cm) of apricot seedlings of local cultivar

| Fe mg. L⁻¹ | Cu mg. L⁻¹ | 0   | 20  | 40   | Average |
|------------|------------|-----|-----|------|---------|
| 0          | 35.33      | 36.33 | 37.67 | 36.44  |
| 30         | 39.00      | 41.67 | 44.00 | 41.56  |
| 60         | 44.67      | 46.00 | 48.33 | 46.33  |
| Average    | 39.67      | 41.33 | 43.33 |         |
| L.S.D 0.05 | Fe 0.456   | Cu 0.456 | interaction 0.790 |

4.2. Root volume (cm³)

The results presented in table 3 indicate that there was a significant effect of iron on the root volume rate. Which showed a concentration of 60 mg.L⁻¹ the highest rate was 23.89 cm³, on the other; the lowest rate was 13.11 cm³ in control treatment. The reason attributed to the efficiency of the root in the absorption of nutrients and water. Then push the plant towards vegetative growth, as well as increase the rate of the number and length of the root in which the construction of cytokines that are transferred to the leaves, thus stimulating cell division and differentiation, which encourages the growth of roots and increase the number and length and thus increase the size of the root total [17].

The effect of copper also had a significant effect on the root volume rate as the treatment of copper achieved at a concentration of 40 mg.L⁻¹ the highest rate of this trait was 20.89 cm³, whereas the seedlings of the control treatment recorded the lowest rate of 16.45 cm³.

The interaction between iron and copper showed a significant effect on the rate of this characteristic; given iron treatment at 60 mg.L⁻¹ and copper at 40 mg.L⁻¹ the highest rate of root volume was 26.33 cm³, while the seedlings in the control treatment gave a lower rate of 11.67 cm³.

Table 3. Effect of iron and copper spraying and their interaction on root volume (cm³) of apricot seedlings of local cultivar

| Fe mg.L⁻¹ | Cu mg.L⁻¹ | 0  | 20  | 40  | Average |
|------------|------------|----|-----|-----|---------|
| 0          | 11.67      | 13.33 | 14.33 | 13.11 |
| 30         | 15.67      | 20.00 | 22.00 | 19.22 |
| 60         | 22.00      | 23.33 | 26.33 | 23.89 |
| Average    | 16.45      | 18.89 | 20.89 |         |
| L.S.D 0.05 | Fe 0.910   | Cu 0.910 | interaction 1.576 |

4.3. Root diameter (cm)

As shown in table 4, there was a significant effect of iron spraying on the rate of this trait. Which gave the treatment of iron at a concentration of 60 mg.L⁻¹. The highest rate of this trait was 2.53 cm compared to the lowest rate of 2.13 cm this may be due to the entry of iron in the composition of cytochrome the elongation of cells leading to increased diameter [18].

The results presented in the same table showed a significant effect of copper on the rate of this characteristic. The spray treatment with copper concentrations of 20 mg.L⁻¹ gave the highest rate of 2.44 cm while the control treatment gave the lowest rate of 2.26 cm. This is due to the role of copper in the transfer of electrons in light reactions in the process of carbon representation. As well as involved in the synthesis of a number of enzymes, including Cytochrome oxidase. Which participates in the division and elongation of cells and then increase the diameters of the roots [10] this result is consistent with what he found [11] between iron and copper, it had no significant effect in this characteristic.
Table 4. Effect of iron and copper spraying and their interaction on root diameter (cm) of apricot seedlings of local cultivar

| Fe mg.l⁻¹ | Cu mg.l⁻¹ | 0     | 20    | 40     | Average |
|-----------|-----------|-------|-------|--------|---------|
| 0         | 2.04      | 2.15  | 2.19  | 2.13   |         |
| 30        | 2.24      | 2.65  | 2.50  | 2.46   |         |
| 60        | 2.49      | 2.52  | 2.58  | 2.53   |         |
| Average   | 2.26      | 2.44  | 2.42  |        |         |
| L.S.D 0.05| Fe 0.158  | Cu 0.158 | n.s   |        |         |

4.4. Dry weight of root (gm. Seedlings⁻¹)
From the results shown in table 5 there are significant differences between iron spraying and control treatment in the dry weight ratio of the root. The treatment of iron spraying at 60 mg.l⁻¹ gave the highest rate of 7.99 gm. Seedlings⁻¹ while the control treatment gave the lowest rate of 5.05 gm. Seedlings⁻¹.

The increase in dry weight as mentioned [17] may be attributed to the efficiency of the root in absorbing nutrients and water. Then pushing the plant towards vegetative growth. As well as increasing the rate of the number and length of the root in which cytokines transferred to the leaves. As well as their role in stimulating cell division and differentiation and then increase the dry weight of the root.

The same table indicated that copper spraying had a significant effect on the dry weight rate of the root. It noticed with copper at the concentration of 40 mg. l⁻¹ gave a significant superiority in this characteristic and reached 7.08 gm. Seedlings⁻¹ compared to the control treatment, which gave the lowest rate of 5.75 gm. Seedlings⁻¹.

The reason for the increase in dry weight of the root may be due to the contribution of this element in some physiological processes of the plant such as carbon representation, as well as the effect of being involved in the synthesis of a number of enzymes and may be reflected on the increase of the process of carbon representation and thus increase the manufacture and accumulation of food, which provides the necessary materials for the growth of the root and increased absorption of nutrients and water [9]. These results are consistent with his findings [11; 12; 13]. The interaction between iron and copper found to have a significant effect on this characteristic. The treatment of iron spraying at a concentration of 60 mg. l⁻¹ and copper at a concentration of 40 mg.l⁻¹ the best on the other treatments, the total dry weight gain of the root was 9.40 gm. seedlings⁻¹ compared to the control treatment of 4.85 gm. seedlings⁻¹.

Table 5 Effect of iron and copper spraying and their interaction on dry weight of root(gm. Seedlings⁻¹) of apricot seedlings of local cultivar

| Fe mg.l⁻¹ | Cu mg.l⁻¹ | 0    | 20    | 40    | Average |
|-----------|-----------|------|-------|-------|---------|
| 0         | 4.85      | 4.94 | 5.36  | 5.05  |         |
| 30        | 5.70      | 5.95 | 6.49  | 6.05  |         |
| 60        | 6.70      | 7.86 | 9.40  | 7.99  |         |
| Average   | 5.75      | 6.25 | 7.08  |       |         |
| L.S.D 0.05| Fe 0.336  | Cu 0.336 | interaction 0.582 | | |
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