Effect of Foliar Application of Sitofex, Potassium and Arginine on Vegetative Growth of "Zaghinia " Apricot Trees

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Abstract. The experiment was carried out at the Agricultural Research and Experiments Station in Al-Sayada site of the College of Agriculture / University of Kirkuk / Republic of Iraq, during the 2020 growing season, on six-year-old "Zaghinia" apricot trees to study the effect of foliar spraying with three concentrations of Sitofex growth regulator (0 and 7.5 and 15 mg L⁻¹), two concentrations of potassium sulfate (0 and 3000 mg L⁻¹) and three concentrations of amino acid (Arginine) (0, 250 and 500 mg L⁻¹). The spraying was carried out a week after the full blooming stage, followed by two sprays with an interval of three weeks. The results indicated that spraying with 15 mg L⁻¹ of Sitofex or spraying with 3000 mg L⁻¹ of potassium sulfate led to a significant increase in all the studied characteristics (length and diameter of shoots, leaf area, total chlorophyll content and dry weight of leaves). As for spraying with amino acid "Arginine", the foliar spray of 500 mg L⁻¹ treatment gave a significant increase in the length and diameter of shoots, leaf area and its total chlorophyll content. Bilateral and triple interference treatments had a significant effect on most of the studied characteristics.

1. Introduction:
Apricot is one of the deciduous fruit crops, which falls under the species prunus and belongs to the Rosaceae family [1]. It was previously believed that the apricot originated in Armenia, but it has become established that the original home of wild apricots was in China and Japan, from which it spread to other regions of the world. The United States of America, Turkey, Italy, France and Syria are among the most important areas for cultivating apricot trees in the world [2]. The importance of apricot trees in economic and nutritional terms is because their fruits contain a lot of minerals and vitamins, where the fruits are used either for fresh food or in dried form. Its fruits are also included in many food industries such as jams, juice, moon, debt, canning, sweets and oil extraction from bitter seeds [3].

Plant growth regulators play an important role in the vegetative growth and productivity of fruits, including Sitofex, which is one of the industrial cytokinins that include Phenylurea in its composition, which prevents or inhibits oxidation of cytokinins. This industrial product was registered under several brand names (CPPU, Sitofex, K30, and Prestije) and was used as a new plant growth regulator on the fruits of kiwi trees and grape vines [4]. One of its most important effects is that, it is characterized by quick cell division, increasing their number, enlarging their size, delaying aging, improving photosynthesis, increasing the single and total leaf area, and extending the life of leaves in food processing [5]. Many researchers showed that foliar spraying of fruit trees with cytokinin CPU improves their vegetative growth. Harhash et al. [6] found an acceptable increase in the shoot length and diameter and leaf area after spraying apple trees, class "I" during the 2015 and 2016 seasons with Sitofex concentrate. 10 mg L⁻¹. When Ali et al. [7] sprayed pear trees with the Sitofex growth regulator, showed
that the concentration of 20 mg L\(^{-1}\) led to an increase in the chlorophyll content of the leaves and the length and diameter of shoots compared to the non-sprayed trees.

Potassium is one of the cations and is needed by high class plants too much, noting that it is not involved with the composition of any organic compound, but it combines with organic acids to form organic salts inside the plant heading to where it is needed within plant tissues. The symptoms of its deficiency appear first on the mature or aged leaves [8]. It participates in many biological processes as a catalyst such as photosynthesis, chlorophyll formation, proteins, and carbohydrate assimilation, as well as regulating the closing and opening of stomata [9]. Medan [10] confirmed that spraying "Royal" apricot trees with potassium sulfate at a concentration of 4000 mg L\(^{-1}\) led to a significant increase in the studied vegetative growth characteristics (Shoot length, leaf area and chlorophyll) compared to the control treatment. As for Judy and Salman [11] found that when "Labib" and "Zaini" apricot trees cultivars were sprayed with potassium sulfate at two levels (0 and 5 g L\(^{-1}\)), they found that the treatment of 5 g L\(^{-1}\) was significantly superior in the leaf area characteristic, which gave an increase of (10.36 and 9.10) % compared to the comparison treatment.

Recently, many researchers have resorted to using amino acids and spraying them on plants because they have an effective role in the physiological and biochemical processes, as they participate in the manufacture of carbohydrates by building protein, chlorophyll, enzymes and enzymatic conjugations and stimulating the process of photosynthesis [12]. Tagabodipour et al. [13] sprayed the amino acid arginine on pistachio trees, and they found that, the treatment 300 micro moles exceeded the control treatment in shoot length and leaf area characteristics.

Therefore, the experiment was conducted to evaluation the effect of "Sitofex", potassium and Arginine on vegetative growth characteristics of "Zaghinia" apricot trees in Kirkuk area.

2. Materials and Methods:
The experiment was conducted at the Agricultural Research and Experiments Station in Al-Sayyada area in the province of Kirkuk - Republic of Iraq and affiliated to the College of Agriculture - University of Kirkuk during the 2020 growing season on Zaghinia apricot trees budded on apricot seedlings rootstock, six-year-old at the experiment beginning. Identical trees as possible in vegetative growth were selected and trained by the modified leader method. They are irrigated by the drip irrigation system, and some physical and chemical properties of the soil were analyzed as shown in Table [1]. An integrated program for field management and tree service was implemented. Manure fertilizer was added to all trees, as well as a fertilization program with nutrients, especially the major ones, as mentioned before [14]. The trees were sprayed with Sitofex growth regulator at three levels (0, 7.5 and 15 mg L\(^{-1}\)), potassium sulfate at two levels (0 and 3000 mg L\(^{-1}\)) and amino acid (Arginine) at three levels (0, 250 and 500 mg L\(^{-1}\)). The first spraying of all treatments took place a week after the full blooming, on 7/3/2020, followed by two sprays with an interval of three weeks. The spray was carried out until complete wetting agent with the use of the diffuser (Hockley N Super) produced by the English company Hockley at a concentration of 0.1 %.

The experiment was carried out according to the randomized complete block design (RCBD) with three replications, and the experimental unit represented one tree. Collected data was analyzed statistically by a computer and SAS program where the averages were compared according to the Duncan polynomial test at a probability level of 0.05 [15].
Table (1) The physical and chemical properties of the orchard soil.

| Soil Texture   | Organic material ( % ) | Clay ( % ) | Available Silt ( % ) | Available Sand ( % ) |
|----------------|-------------------------|------------|----------------------|----------------------|
| Sandy loam     | 0.72                    | 4          | 46                   | 50                   |
| pH             | 7.70                    | 0.93       | 0.053                | 1.60                 | 1.43                 |

2.1. Studied Attributes: All attributes were evaluated on 1- 7/7/2020.

2.1.1. Shoot length (cm): The length of the shoots was measured from the point of its connection with the branch to the end of the shoot by means of the metric ruler.

2.1.2. Shoot diameter (mm): It was measured by the electronic vernier at a distance of (1cm) from the shoot connection to the larger wood.

2.1.3. Leaf area (cm²): 15 leaves from a tree were taken at the middle of the branches for each experimental unit in the first week of August, randomly from different sides of the tree, and were measured based on the Saieed method [16].

2.1.4. Total chlorophyll in leaves (mg g⁻¹): Total chlorophyll was estimated according to the method of Knudson et al. [17].

2.1.5. Leaves' dry matter (%): 20 fully grown leaves were taken from the middle of the shoot for each experimental unit, and they were cleaned then the fresh weight was recorded, and placed in an electric oven at a temperature of 70 ° C for a period of 72 hours until the weight stabilizes, then the dry weight is recorded, and then the percentage of dry matter is calculated according to the following equation:

\[
\text{Dry matter\%} = \left( \frac{\text{dry weight of sample (g)}}{\text{fresh weight of sample (g)}} \right) \times 100.
\]

3. Results and Discussions:

3.1. Shoot length (cm): The results in Table [2] showed that the Shoot length of apricot trees increased significantly when spraying with Sitofex at a concentration of 15 mg L⁻¹, reaching 38.38 cm, with an increase of 7.89% over the comparison treatment. The spray treatment with a concentration of 3000 mg L⁻¹ of potassium sulfate significantly outperformed the comparison treatment, reaching 37.16 cm, with an increase of 2.17%. The spray with arginine at a concentration of 500 mg L⁻¹ significantly outperformed the comparison treatment, as it gave shoot of 37.60 cm in length, with an increase of 4.24% over the comparison treatment. As for the bilateral interaction between levels of Sitofex and potassium sulfate, the treatment of 15 mg L⁻¹ Sitofex plus 3000 mg L⁻¹ potassium sulfate significantly exceeded the remaining treatments, reaching 38.78 cm. The interaction treatment of 15 mg L⁻¹ Sitofex and 500 mg L⁻¹ arginine had a significant effect in increasing the length of shoots, reaching 38.90 cm. The treatment of 3000 mg L⁻¹ potassium sulfate- 500 mg L⁻¹ arginine had a significant effect on the remaining treatments, as it reached 37.88 cm compared to the comparison treatment. The triple-interference treatment between 15 mg L⁻¹ Sitofex, 3000 mg L⁻¹ potassium sulfate, and 500 mg L⁻¹ arginine significantly outperformed the all-other treatments, reaching 39.47 cm.
Table (2) Effect of foliar application with Sitofex, potassium, arginine and their interactions on shoot length of "Zaghinia" apricot trees

| Sitofex (mg L⁻¹) | Arginine (mg L⁻¹) | potassium sulfate (mg L⁻¹) | Sitofex* Arginine |
|-----------------|-----------------|-----------------|-----------------|
|                 |                 | 0               | 3000            |
| 0               | 0               | 33.27 j         | 35.43 hi        | 34.35 f         |
| 0               | 250             | 35.15 i         | 35.83 ghi       | 35.49 e         |
| 500             | 36.67 ef        | 37.04 de        | 36.86 c         |
| 7.5            | 0               | 35.50 hi        | 36.12 fgh       | 35.81 de        |
| 250            | 35.80 ghi       | 36.50 efg       | 36.15 d         |
| 500            | 36.97 e         | 37.13 de        | 37.05 c         |
| 0              | 37.73 cd        | 38.35 bc        | 38.04 b         |
| 250            | 37.88 bc        | 38.53 b         | 38.21 b         |
| 500            | 38.34 bc        | 39.47 a         | 38.90 a         |

Sitofex Average: 35.57 c
Potassium sulfate Average: 35.37 b

The averages that share the same alphabet for each factor and each interaction do not differ significantly between them according to Duncan's polynomial test at a probability level of 0.05.

3.2. Shoot diameter (mm): The results in Table [3] showed that the Shoot diameter of apricot trees increased significantly when spraying with Sitofex at a concentration of 15 mg L⁻¹, reaching 5.99 mm, while the comparison treatment for this characteristic gave the lowest rates, which reached 5.38 mm. The spray treatment with a concentration of 3000 mg L⁻¹ of potassium sulfate significantly exceeded the comparison treatment, reaching 5.73 mm. The spray with arginine at a concentration of 500 mg L⁻¹ significantly outperformed the comparison treatment, giving shoots of 5.86 mm diameter and a 5.97% increase over the comparison treatment.

The interaction treatment of 15 mg L⁻¹ of Sitofex, interfering with 3000 mg L⁻¹ of potassium sulfate, was significantly superior to the remaining treatments, reaching 6.09 mm. The interaction with a concentration of 15 mg L⁻¹ of Sitofex with 500 mg L⁻¹ of arginine significantly outperformed the rest of the treatments and reached 6.08 mm. As for the interaction between the levels of potassium sulfate and arginine, the treatment with a concentration of 3000 mg L⁻¹ potassium sulfate and 500 mg L⁻¹ arginine had a significant effect on the leaf area characteristic, as it surpassed the remained treatments, reaching 5.93 mm. As for the triple interaction between levels of Sitofex, potassium sulfate and arginine, the results of the same table indicated that the superiority of the treatment with a concentration of 15 mg L⁻¹ Sitofex 500 mg L⁻¹ arginine and 3000 mg L⁻¹ potassium sulfate over the remaining treatments, reaching 6.20 mm, with an increase of 23.50% over the comparison treatment.

Table (3) Effect of foliar application with Sitofex, potassium, arginine and their interactions on shoot diameter of "Zaghinia" apricot trees

| Sitofex (mg L⁻¹) | Arginine (mg L⁻¹) | potassium sulfate (mg L⁻¹) | Sitofex* Arginine |
|-----------------|-----------------|-----------------|-----------------|
|                 |                 | 0               | 3000            |
| 0               | 0               | 5.02 g          | 5.39 f          | 5.21 e          |
| 0               | 250             | 5.08 g          | 5.37 f          | 5.22 e          |
| 500             | 5.67 de         | 5.75 d          | 5.71 c          |
| 7.5            | 0               | 5.42 f          | 5.49 ef         | 5.45 d          |
| 250            | 5.46 f          | 5.51 ef         | 5.49 d          |
| 500            | 5.72 d          | 5.83 cd         | 5.77 c          |
| 15              | 0               | 5.83 cd         | 6.00 bc         | 5.92 b          |
| 250            | 5.87 cd         | 6.07 ab         | 5.97 ab         |

The averages that share the same alphabet for each factor and each interaction do not differ significantly between them according to Duncan's polynomial test at a probability level of 0.05.
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### 3.3. leaf area (cm²): The data in Table (4) shows that the area of leaf was significantly affected when spraying with a concentration of 15 mg L⁻¹ of Sitofex, which reached 19.12 cm², with an increase of 7.11% over the comparison treatment. Spraying trees with potassium sulfate at a concentration of 3000 mg L⁻¹ had a significant effect on increasing the leaf area, reaching 18.56 cm², with an increase of 2.20% over the comparison treatment. 2.14% increase over the comparison treatment. The treatment of bilateral interaction between the levels of Sitofex and potassium sulfate at a concentration of 15 mg L⁻¹ Sitofex and 3000 mg L⁻¹ potassium sulfate significantly exceeded the rest of the treatments in increasing the area of one leaf, reaching 19.33 cm². The treatment with a concentration of 15 mg L⁻¹ of Sitofex, intertwined with a concentration of 500 mg L⁻¹ of arginine, was significantly superior to the rest of the treatments, as it reached 19.27 cm². As for the bilateral interaction between potassium sulfate and arginine levels, the treatment 3000 mg L⁻¹ potassium sulfate and 500 mg L⁻¹ arginine had a significant superiority over the rest of the treatments, which amounted to 18.72 cm².

The triple interaction among levels of Sitofex, potassium sulfate and arginine had a clear significant effect in increasing the area of leaf, as the treatment with a concentration of 15 mg L⁻¹ Sitofex, 3000 mg L⁻¹ potassium sulfate, and 500 mg L⁻¹ arginine was significantly superior to the rest of the treatments reaching to 19.47 cm².

| Sitofex (mg L⁻¹) | Arginine (mg L⁻¹) | potassium sulfate (mg L⁻¹) | Sitofex* Arginine Average |
|-----------------|------------------|---------------------------|---------------------------|
| 0               | 0                | 17.47 k                   | 17.66 f                   |
| 250             | 17.63 jk         | 17.93 ghij                | 17.78 ef                  |
| 500             | 18.07 ghij       | 18.17 fgh                 | 18.12 d                   |
| 0               | 17.64 jk         | 18.27 fg                  | 17.96 de                  |
| 250             | 17.71 ljk        | 18.28 fg                  | 17.99 de                  |
| 500             | 18.20 fgh        | 18.52 ef                  | 18.36 c                   |
| 0               | 18.75 de         | 19.14 abc                 | 18.95 b                   |
| 250             | 18.90 cd         | 19.37 ab                  | 19.14 ab                  |
| 500             | 19.07 cd         | 19.47 a                   | 19.27 a                   |

The averages that share the same alphabet for each factor and each interaction do not differ significantly between them according to Duncan's polynomial test at a probability level of 0.05.
3.4. **Dry matter in leaves (%):** The results of Table (5) indicated that spraying apricot trees with a concentration of 15 mg L\(^{-1}\) of Sitofex had a significant effect in increasing the percentage of dry matter in leaves, reaching 48.14%, with an increase of 7.48% over the comparison treatment. The spray with a concentration of 3000 mg L\(^{-1}\) of potassium sulfate significantly exceeded the comparison treatment, with an increase of 2.76%, whereas the spray with arginine did not show any significant effect in this aspect.

| Sitofex (mg L\(^{-1}\)) | Arginine (mg L\(^{-1}\)) | Potassium Sulfate (mg L\(^{-1}\)) | Sitofex* Arginine |
|--------------------------|--------------------------|----------------------------------|-------------------|
| 0                        | 0                        | 0                                | 45.12 d           |
| 250                      | 44.40 g                  | 46.10 de                         | 45.70 de          |
| 500                      | 43.73 g                  | 45.37 ef                         | 44.55 e           |
| 7.5                      | 0                        | 45.36 ef                         | 46.66 d           |
| 250                      | 45.86 def                | 46.45 d                          | 46.16 c           |
| 500                      | 45.07 f                  | 46.33 d                          | 45.70 c           |
| 0                        | 47.70 bc                 | 49.37 a                          | 48.54 a           |
| 15                       | 250                      | 47.60 bc                         | 48.37 b           |
| 500                      | 47.49 c                  | 48.30 b                          | 47.99 b           |
| Sitofex Average          |                          |                                  |                   |
| Arginine * Potassium Sulfate (mg L\(^{-1}\)) | | | |
| 0                        | 43.97 e                  | 45.61 d                          | 44.79 c           |
| 7.5                      | 45.43 d                  | 46.48 c                          | 45.96 b           |
| 15                       | 47.59 b                  | 48.68 a                          | 48.14 a           |
| Arginine Average         |                          |                                  |                   |
| Potassium Sulfate Average |                          |                                  |                   |
| 0                        | 45.73 c                  | 47.38 a                          | 46.55 a           |
| 250                      | 45.83 c                  | 46.73 b                          | 46.28 ab          |
| 500                      | 45.43 c                  | 46.67 b                          | 46.05 b           |

The averages that share the same alphabet for each factor and each interaction do not differ significantly between them according to Duncan’s polynomial test at a probability level of 0.05.

The bilateral interaction between levels of Sitofex and potassium sulfate had a clear significant effect in the characteristic of the dry matter ratio in the leaves, as the treatment with a concentration of 15 mg L\(^{-1}\) Sitofex and 3000 mg L\(^{-1}\) potassium sulfate outperformed the rest of the treatments and reached 48.68%. As for the interaction between the levels of Sitofex and arginine, the treatment with a concentration of 15 mg L\(^{-1}\) Sitofex and zero-mg L\(^{-1}\) arginine showed a significant effect, reaching to 48.54%, and outperforming the rest of the treatments. The interaction treatment with a concentration of 3000 mg L\(^{-1}\) potassium sulfate and zero mg L\(^{-1}\) arginine significantly outperformed the remaining treatments, which reached to 47.38%. Whereas, the triple interaction treatment of 15 mg L\(^{-1}\) Sitofex, 3000 mg L\(^{-1}\) potassium sulfate, and zero-mg L\(^{-1}\) arginine significantly outperformed the other treatments with respect to the dry matter rate characteristic of leaves, reaching 49.37%.

3.5. **Total chlorophyll (mg g\(^{-1}\)):** The table (6) results showed that spraying trees with Sitofex led to an increase in their leaf content of total chlorophyll, where the spraying treatment with a concentration of 15 mg L\(^{-1}\) of Sitofex was significantly higher, with an increase of 22.56% over the comparison treatment. The spray treatment with a concentration of 3000 mg L\(^{-1}\) of potassium sulfate significantly outperformed the comparison treatment, with an increase of 9.76%. Also, the spray treatment with a concentration of 500 mg L\(^{-1}\) of arginine significantly outperformed the comparison treatment, with an increase of 3.64%.
Table (6) Effect of foliar application with Sitofex, Potassium, Arginine and their interactions on Total chlorophyll in leaves of "Zaginia" apricot trees

| Potassium Sulfate (mg L⁻¹) | Sitofex (mg L⁻¹) | Arginine (mg L⁻¹) | Total Chlorophyll (mg g⁻¹) |
|---------------------------|------------------|-------------------|---------------------------|
| 0                         | 0                | 0                 | 14.56 i                   |
| 250                       | 13.30 q          | 16.78 o           | 15.33 h                   |
| 500                       | 14.35 p          | 17.59 i           | 15.97 g                   |
| 7.5                       | 17.51 m          | 18.10 i           | 17.81 f                   |
| 0                         | 17.72 k          | 18.12 h           | 17.92 e                   |
| 250                       | 17.92 j          | 18.18 g           | 18.05 d                   |
| 500                       | 18.37 f          | 18.99 b           | 18.68 b                   |
| 15                        | 18.38 e          | 18.92 c           | 18.60 c                   |
| 250                       | 18.57 d          | 19.24 a           | 18.91 a                   |
| 500                       | 18.74 a          | 19.07 a           | 18.44 b                   |

The averages that share the same alphabet for each factor and each interaction do not differ significantly between them according to Duncan's polynomial test at a probability level of 0.05.

As for the bilateral interaction between levels of Sitofex and potassium sulfate, the interaction treatment of 15 mg L⁻¹ Sitofex and 3000 mg L⁻¹ potassium sulfate significantly exceeded the remained treatments and gave the highest leaf content of total chlorophyll, 19.07 mg g⁻¹ fresh weight. The bilateral interaction treatment between 15 mg L⁻¹ Sitofex, and 500 mg L⁻¹ arginine showed a significant effect on total chlorophyll content in the leaves reached 18.91 mg g⁻¹ fresh weight. As for the interaction treatment between 3000 mg L⁻¹ of Potassium sulfate and 500 mg L⁻¹ of L-arginine, it significantly outperformed the remained treatments, reaching 18.34 mg g⁻¹ fresh weight. The triple interaction among the levels of Sitofex, potassium sulfate and arginine had a significant effect in increasing the leaf content of total chlorophyll, where the interaction treatment 15 mg L⁻¹ Sitofex, 3000 mg L⁻¹ potassium sulfate and 500 mg L⁻¹ arginine significantly dominated over the rest of the treatments and gave the highest value of chlorophyll was 19.24 mg g⁻¹ fresh weight. The positive role of Sitofex in increasing the length and diameter of the shoots and dry matter in the leaves can be attributed to its role in cell division and is also an important factor in the regulation and distribution of photosynthesis products and nutrients towards the growth points in plants as well as stimulating the formation of a single species or more of the proteins related to chlorophyll [18 and 19]. When spraying Sitofex, it also increased the leaf area and its content of chlorophyll, due to the role of CPPU in protecting the leaves. It reduces aging and development of chloroplasts and delays protein degradation, in addition to its role in increasing the activity of the enzyme protoclorophyllid reductase - NAPH, which is used in the biosynthesis of chlorophyll and thus increases this pigment [20 and 21]. These results agree with the findings of Elgendy et al. [22] and Abd-Allatif [23].

As for the positive effect of potassium on the growth characteristics when was sprayed on apricot trees, it is attributed to its role in increasing the surface area of the leaves, which increases the carbohydrates that are manufactured in the process of photosynthesis and their ease of transportation to the active centers and help in the process of cell division, as well as its role in the process of opening and closing Stomata and the regulation of membranes permeability [24]. Also, spraying with potassium increased the content of chlorophyll in leaves, and this may be due to the importance of potassium in delaying the aging of leaves due to its role in delaying protein catabolism and raising the efficiency of photosynthesis. Deficiency in potassium leads to a decrease in the energy complex of ATP and a decrease in the transport system inside the plant, which leads to the accumulation of products of the photosynthesis
process in the leaves in addition to a decrease in the rate of this process that affects the manufacture and production of chlorophyll [25 and 26]. These results are consistent with what was found by Hadi et al. [27] and Mosa et al. [28].

As for the effect of spraying with amino acid mentioned in the studied characteristics, it may be due to its role in reducing the water stress of the cell, as the ability of the cell to absorb water and dissolved nutrients in it from the growth medium increases. Consequently, it leads to an increase in the vegetative growth of trees, and the increase in the proportion of chlorophyll in the leaves is related to the moving nitrogen in amino acids [29]. These results are consistent with the findings of Al-asadi [30], Abd El-Aal et al. [31].

4. Conclusions:
It can be concluded from this study that the three factors (Sitofex, potassium and the amino acid "arginine") played an effective role in improving the vegetative growth characteristics of apricot trees of Zaghinia cultivar under the conditions of the region. The interaction treatments among them, whether double or triple, increased the effectiveness of each where the best results were at interaction high levels of each.

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