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Response of apricot trees for spraying by antioxidants compounds and foliar fertilizers

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ABSTRACT

The study was conducted on apricot trees, variety Zaghenia aged 15-20 years in the Karbala govern, Huseeinia during the growth season 2018-2019. It included spraying of the foliar fertilizer Oligo Azoren Mix contained a group of nutritional microelement as well as magnesium at two concentrations (0 and 1.5 mg.L^{-1}). The study also included antioxidants consisted of Propyl Gallate at two concentrations (200 and 300 mg.L^{-1}) and ascorbic and citric acids at two concentrations (500 and 1000 mg.L^{-1}) of each, in addition to the control treatment of spraying just water. The study was conducted according to the Randomized Complete Block Design (RCBD) as a factorial (2*7) experiment of three replicates for each treatment.. The results can be summarized as follows. The concentration 1000mg.L^{-1} gave significant increments in most studied traits including leaf area, chlorophyll content, carbohydrate amount, fruit set percentage, fruit size, and tree yield. Propyl Gallate achieved the best increment at the lower concentrations compared to the other study factors where its concentration 200mg.L^{-1} enhanced the two traits, leaf area and carbohydrate amount and the concentration 300 mg.L^{-1} enhanced the traits chlorophyll content, fruit set percentage, and fruit,The foliar fertilizer significantly affected some studied traits included carbohydrate amount and tree yield.

Kay words : *Prunus armeniaca L., Foliar fertilizers, Ascorbic acid, Galic acid*

Introduction

Apricot ***Prunus armeniaca L.*** belongs to the Rosaceae family of deciduous fruit with a stone core. Apricot tree is characterized by rapid growth, can begin to bear fruit within 4-3 years. Fruits are borne laterally on one-year aged branches or on short aged spurs (El-Issa and Batha, 2012). All pieces of evidence indicate that the original home of apricots is China, where man cultivated it more than 2000 years BC and from China, its cultivation has moved to Europe and other world countries including Turkey, Iran, and some Arabian countries (Hamed *et al.*, 2007). The success of growing apricot trees requires providing them with the nutrients. Foliar fertilization is one of the important approaches for avoiding the nutrient element deficiency and overcoming their lack of availability in the soil especially the microelement nutrients (Kessel, 2006; Bocharov, 2007). Using microelements in the foliar fertilizing is considered a successful approach to deal with the nutrient deficiency symptoms in plants (Alexander, 1986) .phytohormones are considered the most important endogenous substances for modulating physiologicala and molecular responses (AL-Taey, 2010) play important role as antioxidant compounds like Propyl Gallate, Ascorbic and Citric acids,Antioxidants have distinguished importance in the agricultural field where a lot of research refers to their role in enhancing the fruit quality and increasing the yield of many different fruit trees. They are non-enzymatic materials have a beneficial effect on catching the free radicals that are constructed biologically during the plant metabolism processes, as leaving these radicals without catching leads to fat oxidation and losing the plasmatic membranes the permeable characteristic and then the plant cell and tissue death (Elada, 1992; Prusky, 1988). Propyl Gallate-N is common oxidant Known by other names such as E310 and Propyl ester used for fruit and vegetable storage in addition to other foods commonly used nowadays. It consists of three hydroxide groups making it highly active. It is derived from the Gallic acid that is a phenolic acid and natural compound existed in some plants and has a scavenging or cleaning effect on the free radicals (Ayuyan, 2006). One of the other antioxidants is ascorbic acid (Vitamin C). It stimulates the vegetative and fruit growth of different fruit trees in a way similar to the growth regulator effect (Ahmed *et al.,* 1997; Johnson, 1999). Citric acid is also a common antioxidant widely used in the agricultural area for it is not expensive and available in the markets (Tuzun, 2007). It plays an important role in converting sugar into water and carbon dioxide through the Krebs Cycle and in enhancing the function and stability of membranes (Mansour *et al.,* 2008). Foliar fertilizing or foliar feeding with nutrients can be absorbed byleaves or other parts of the plant like fruits and stems to provide the plant withthe nutrients it needs, entering through the cell envelope by water, and diffusion (AL-Taey*et al*.,2018; Hasan,*et al*.,2019)This study aims to investigate the effect of the interaction between the antioxidants and nutrient elements on the growth and production of apricot trees, variety Zaghenia, in addition to the effect of Propyl Gallate-N on increasing the fruit set and decreasing the fruit falling.

Materials and Methods

Carrying out the study

The study was carried out on apricot trees, variety Zaghenia, at a private orchard in the governance of Karbala, Husseinia during the two growth seasons 2018 and 2019. Forty- two, relatively vegetative homogeneous trees were selected. They were aged 18 years and separated from each other by 5*5 m distance. The service operations including weeding, irrigation and pest control were performed systematically before and during the study.

Study factors and experimental design

The study included

First factor: spraying the antioxidants

- Without spray (the control treatment), symbolized by Z, i.e. spraying water only
- Propyl Gallate, at the concentrations 200 and 300 $mg.L^{-1}$, referred to by the symbols p1 and p2 respectively (Gill *et al.,* 2016).
- Ascorbic acid at the concentrations 500 and 1000 $mg.L^{-1}$, referred to by the symbols A1 and A2 respectively (El-Badawy *et al.,* 2017).
- Citric acid at the concentrations 500 and 1000 $mg.L^{-1,}$ referred to by the symbols C1 and C2 respectively
- Second factor: spraying the nutrient fertilizer Oligo Azoren Mix (Table 1) at the two concentrations 0 and 1.5 $g.L^{-1}$

The first spray of all the factors was during the late of September 2018, while the second one was during March 2019 at the full flowering stage, then it was repeated every 20 days to become 4 sprays as a whole and a little of detergent was added with each treatment as a scattering material. Spray procedure included spraying the antioxidant the day before and then spraying the fertilizer the next day immediately to prevent the fixation of the elements contained in the fertilizer because the antioxidants might reduce the solution pH to 4 ± 1 while the fertilizer prescription mentions that it would be fixed at the pH 4. A factorial experiment (2*7) was conducted according to the Randomized Complete Block Design (RCBD) included three replicates where each treatment was represented by a tree. Data were analyzed depending on the software Genstat (2003), then the means were compared using the L.S.D at the probability 0.05 (Al-Sahoky and Waheeb, 1990).

Table 1. The ingredients of the mineral fertilizer Oligo Azoren Mix

Nutritional element	Percentage
Boron (B)*	1.5 % weight/weight
Cooper (Cu)**	0.6 % weight/weight
Iron (F2)**	4% weight/weight
Manganese (Mn)**	3% weight/weight
Molybdenum (Mo)*	0.05% weight/weight
Zinc (Zn)**	4% weight/weight
Magnesium oxide (Mgo)*	1.1% weight/weight

(*) water soluble, (**) chelated on EDTA and water soluble

Study indicators

1. Leaf area (cm^2), Leaf chlorophyll content ($mg.g^{-1}$fresh weight), Annual branch content of soluble carbohydrates ($mg.g^{-1}$ dry weight)by (Herbert *et al.*, 1971),
2. Fruit set percentage % by (Al-Hadethi and Al-Rawi, 2009) equation

$$\text{fruit set percentage} = \frac{\text{set fruit number}}{\textit{number of flowers}}\ x\ 100$$

3. Fruit size average (cm^3) was measured to calculate the fruit size average by dividing the result by the fruit number.

Results and Discussion

First: vegetative system measurements

Leaf area (cm^2)

Table 2 refers to the effect of spraying the foliar fertilizer, Oligo Azoren Mix, and the antioxidant on the leaf area of apricot trees var. Zaghenia. The results did not illustrate any significant effect of the foliar fertilizer on this trait. Concerning the effect of the antioxidants, the treatment of 1000 $mg.L^{-1}$ of ascorbic acid (A2) gave the highest leaf area (38.4 cm^2), but the leaf area decreased to 21.8 cm^2 as a result of treating by 500 $mg.L^{-1}$ of citric acid, on the other hand applying the other antioxidants did not differ significantly from the control treatment in this trait.

The effect of the interaction between the treatments of the foliar fertilizer with antioxidants was significant where the treatment F1C1 produced the highest plant leaf area (40.3 cm^2) surpassing the most treatments especially the control treatment and the treatment F0C1 producing 28.7 cm^2 and 20.8 cm^2 respectively. The reason behind the superiority of ascorbic acid is due to its role in increasing the chlorophyll content in the leaves (Table 3), thus increased the photosynthesis efficiency affecting the products positively and providing the energy for the plant to perform other processes such growth and construction (Kramer and Kozlowski, 1979). In

Table 2. Effect of spraying foliar fertilizer Oligo Azoren Mix and antioxidants on the leaf area (cm^2)

Foliar fertilizer/ antioxidant	F0	F1	Antioxidant mean
Z	28.7	37.0	32.9
P_1	34.8	36.2	35.5
P_2	32.7	29.3	31.0
A_1	29.8	28.5	29.2
A_2	37.8	38.9	38.4
C_1	20.8	22.9	21.8
C_2	33.0	40.3	36.7
Foliar fertilizer mean	31.1	33.3	32.214
L.S.D %5	Foliar fertilizer n.s	Antioxidant 11.34	Interaction 16.04

Table 3. Effect of spraying foliar fertilizer Oligo Azoren Mix and antioxidants on the leaf chlorophyll content (mg.g-1 fresh wight)

Foliar fertilizer /Antioxidant	F0	F1	Antioxidant mean
Z	1.493	1.677	1.585
P_1	2.140	2.073	2.107
P_2	2.280	1.956	2.118
A_1	2.170	2.260	2.113
A_2	1.967	2.323	2.247
C_1	1.820	1.850	1.835
C_2	1.707	1.947	1.827
Foliar fertilizer mean	1.940	2.012	1.976
L.S.D %5	Foliar fertilizer n.s	Antioxidant 0.3087	Interaction 0.4353

addition to its role, mentioned earlier, in cell division, enlargement, and distinguishing, ascorbic acid is known as a helping substance contributing to organizing the growth processes and plant development consequently increasing the plant leaf area (Abd El-Aziz *et al.*, 2006). On the other hand, the reason of reducing the leaf area resulted from treating by citric acid (C1) was due to its role in increasing the number of leaves that affected the leaf area negatively (Table 6).

Leaf chlorophyll content (mg.g^{-1} fresh weight)

It is shown by Table 3 the effect of spraying foliar fertilizer and antioxidants on chlorophyll content in the leaves where the foliar fertilizer did not affect the trait significantly, whereas the antioxidants demonstrated a significant superiority of all treatment, compared to the control treatment, especially the treatment of spraying 1000 mg.L^{-1} of ascorbic acid (A2) producing 2.247 mg.g^{-1} fresh weight followed by the treatment of spraying Propyl Gallate at the concentration 300 mg.L^{-1} (P2) which did not differ significantly from the control treatment producing 1.585 mg.g^{-1} fresh weight.

Regarding the interaction between the foliar fertilizer and antioxidant, the table reveals that the treatment F1A2 was superior in increasing the chlorophyll content in the apricot tree leaves to 2.323 mg.g^{-1} fresh weight, while it was decreased to 1.493 as a result of the treatment F0Z. The superiority of ascorbic acid treatment may be attributed to its role, as an antioxidant, in maintaining the chlorophyll pigment constructed inside the leaf against the oxidative damage caused by the high temperature and sunshine during the summer season (Oertli, 1987). Ascorbic acid also may increases the plant efficiency at absorbing elements from the soil, including iron and magnesium, leading to increasing their concentration in the leaves as it is known they are necessary and important for the chlorophyll molecule construction (Fayed, 2010). Furthermore, the active formula of iron in the electron transfer in the cells is Fe+2 which is important for chlorophyll molecular synthesis and what enhances increasing this for-

Table 4. Effect of spraying foliar fertilizer Oligo Azoren Mix and antioxidants on the total soluble carbohydrates content (mg.g^{-1} dry weight)

Foliar fertilizer /antioxidant	F0	F1	Antioxidant mean
Z	9.070	9.889	9.479
P_1	10.541	10.801	10.671
P_2	10.317	10.739	10.528
A_1	10.438	11.162	10.800
A_2	10.337	11.265	10.801
C_1	9.784	9.834	9.809
C_2	9.581	9.967	9.774
Foliar fertilizer mean	10.010	10.522	10.266
L.S.D %5	Foliar fertilizer	Antioxidant	Interaction
	0.2657	0.4970	0.7029

Table 5. Effect of spraying foliar fertilizer Oligo Azoren Mix and antioxidants on the fruit set percentage (%)

Foliar fertilizerantioxidant	F0	F1	Antioxidant mean
Z	35.3	38.6	37.0
P_1	48.3	46.7	47.5
P_2	44.7	50.5	47.6
A_1	49.3	41.4	45.4
A_2	48.7	52.0	50.3
C_1	44.0	35.4	39.7
C_2	40.0	42.0	41.0
Foliar fertilizer mean	44.3	43.8	44.1
L.S.D %5	Foliar fertilizer	Antioxidant	Interaction
	n.s	11.31	16.00

mula of iron is ascorbic acid (Crane *et al.,* 2007).

The treatment of spraying Propyl Gallate on the vegetative system had a role in increasing the chlorophyll amount in the leaves as a result of its role in eliminating the free radicals including $O^{=}$ and preventing or slowing their accumulating inside plant tissues, consequently it maintainsthe tissue vitality, delays the senility, and prevent destroying the chlorophyll pigment (Sorres *et al.,* 2003).

Annual branch content of soluble carbohydrates (mg.g^{-1} dry weight)

Results in Table 4 reveal significant differences among the treatments of spraying foliar fertilizer Oligo Azoren Mix where the treatment of spraying 1.5 g.L^{-1} (F1) was significantly superior producing 10.522 mg.g^{-1} dry weight compared to the control treatment producing 10.010 mg.g^{-1} dry weight.

The treatments of spraying antioxidants showed significant differences represented by the treatment of 1000 mg.L^{-1} ascorbic acid (A2) which was superior in increasing the total soluble carbohydrates in the branches to 10.801 mg.g^{-1} dry weight that did not differ significantly from the treatment of spraying ascorbic acid at the concentration 500 mg.L^{-1} producing 10.800 mg.g^{-1} dry weight. These were followed by the treatments of Propyl Gallate sprayed at low concentrations compared to the others, nevertheless it affected this trait clearly where the carbohydrates content 10.671 and 10.671mg.g^{-1} dry weight was obtained from the treatments of 200 mg.L^{-1} (P1) and 300 mg.L^{-1} (P2) respectively, however, they did not differ from each other significantly. As for the control treatment, the annual branch content of soluble carbohydrates was decreased to 9.479 mg.g^{-1} dry weight.

The interaction treatments between the of foliar fertilizer and antioxidants showed the superiority of the treatment F1A2 giving carbohydrate content of 11.265 mg.g^{-1} dry weight that was decreased affected by the control treatment F0Z to 11.162 mg.g^{-1} dry weight.

The reason behind this effect may be attributed to role of the foliar fertilizer in supplying the plant with nutrient elements leading to enhancing the photosynthesis efficiency that consequently increases the available carbohydrates (Nafie, 1984); moreover, each nutrient element has supplied by the foliar fertilizer has its own function enhancing the vital processes within plants all of them leading to providing essential carbohydrates (Abo – Dhahiand Al-Yonis, 1988; Abbas and Hasan, 2018).

The superiority of spraying ascorbic acid might be due to what was previously mentioned about the two traits of chlorophyll (Table 3) and leaf area (Table 2) that increase the photosynthesis efficiency since the chlorophyll is an essential pigment for this process as well as the ascorbic acid role in activating many processes as a catalyst or coenzyme for many enzymes responsible for the metabolism of carbohydrates and proteins, in addition to its role in organizing the processes of cell division and enlargement (Blokhina *et al.,* 2003). It also affects the ratio between photosynthesis and respiration in favor of photosynthesis, which provides a much amount of carbohydrates for the plant (Lall and Dhopte, 1981).

The Propyl Gallate role in enhancing this trait was through increasing the activity and effectiveness of many enzymes including Catalase (CAT) that degenerates the excess hydrogen hydroxide i.e. eliminating its toxic effect and maintaining the chlorophyll pigment constructed inside the leaves and

Table 6. Effect of spraying foliar fertilizer Oligo Azoren Mix and antioxidants on fruit size (cm^3)

Foliar fertilizer/ antioxidant	F0	F1	Antioxidant mean
Z	30.07	32.03	31.05
P_1	37.90	30.43	34.17
P_2	36.00	41.87	38.93
A_1	40.07	42.10	41.08
A_2	42.73	41.53	42.13
C_1	33.00	31.54	32.27
C_2	31.80	35.27	33.53
Foliar fertilizer mean	35.94	36.40	36.17
L.S.D %5	Foliar fertilizer	Antioxidant	Interaction
	n.s	3.353	4.742

then increasing the carbohydrates produced as a result the photosynthesis process (Feixu *et al.*, 2012).

Second: yield traits

Fruit set percentage%

Results of Table 5 illustrates that the effect of spraying the foliar fertilizer Oligo Azoren Mix and antioxidants on the fruit set percentage of apricot trees, var. Zaghenia was not significant, while the treatment of spraying 1000 mg.L^{-1} of ascorbic acid (A2), one of antioxidants, increased the fruit set percentage to 50.3% followed by the two treatments of Propyl Gallate, 200 ng.L^{-1} (P1) and 300 mg.L^{-1} (P2) that produced 47.5 and 47.6% respectively whereas the control treatment gave the lowest percentage (37%). For the interaction treatments, the treatment F1A2 produced the highest percentage of the fruit set (52%) and superior to the control treatment where the fruit set percentage was only 34.3%.

The reason of ascorbic acid superiority might be due to its positive role in the growth indicators and nutrition status of the trees that surely reflects on increasing the fruit set of the trees (Wassel *et al.*, 2007), as well as its role in increasing the chlorophyll content (Table 3) and the leaf area (Table 2) that enhances the leaf efficiency through increasing the photosynthesis efficiency and then providing the essential substances including the saccharides required for the vital processes within plant such as division, enlargement, and differentiation of the cells. This acid acts as a catalyst and coenzyme in many enzymatic and non-enzymatic reactions frequently happening during the processes of pollination, fertilization, and fruity set (Dhopte and Lall, 1987; Blokhina *et al.*, 2003; Bassuony *et al.*, 2008). In addition to the ascorbic acid effective role in some enzymes' activity, it helps in coordinating with other antioxidants to reduce oxidation damages (Noctor and Foyer, 1998). Furthermore, it participates in increasing the vegetative system growth through increasing the leaf area (Table 2), the chlorophyll content (Table 3), and the carbohydrate amount (Table 4), thus it enhances the photosynthesis process required for the pollination and fertilization and provides an increment in the nutrition element concentrations essential for developing the flower meristem tissues leading to increasing the fruit set (Taylorand Goubran, 1975).

Fruit size (cm^3)

Table 6 demonstrates that the effect of the foliar fertilizer Oligo Azoren Mix on the fruit size of the apricot fruits, var. Zaghenia was insignificant while spraying the antioxidant increased the fruit size significantly. Spraying 1000 mg.L^{-1} of ascorbic acid (A2) was superior giving the highest apricot fruit size averaged 42.13 cm^3 followed by the two treatment P1 and A1producing 38.93 and 41.08 cm^3 respectively which all of them were higher than the control treatment producing fruits sized 31.05 cm^3. Concerning the interaction treatments, the treatment F0A2 was superior producing 42.73 cm^3 compared to the control treatment producing 30.07 cm^3.

The cause of this superiority may be due to the direct effect of ascorbic acid on the biosynthesis of amino acids that would convert into proteins later on (Bassuony *et al.*, 2008), or to its role in activating and increasing the cell division and elongation within plant tissues (Blokhina *et al.*, 2003), as well as its role in organizing the bioprocesses related to the cell differentiation in a way similar to the behavior of growth regulators growing fruit parts and leading to a size increment (Blokhina *et al.*, 2003; Abd El-

Table 7. Effect of spraying foliar fertilizer Oligo Azoren Mix and antioxidants on tree yield (kg.tree^{-1})

Foliar fertilizer/ Antioxidant	F0	F1	Antioxidant mean
Z	11.00	16.00	13.50
P_1	13.00	15.67	14.33
P_2	14.33	15.00	14.67
A_1	17.00	17.33	17.17
A_2	18.33	22.00	20.17
C_1	16.00	13.63	14.81
C_2	15.00	16.00	15.50
Foliar fertilizer mean	14.95	16.52	15.74
L.S.D %5	Foliar fertilizer	Antioxidant	Interaction
	0.871	1.630	2.306

Aziz *et al.,* 2006). Furthermore, the treatment of spraying ascorbic acid led to the best results regarding the traitsof chlorophyll content (Table 3), leaf area (Table 2), and carbohydrate amount (Table 4) all had a positive effect on the fruit traits.

Yield per a tree (kg)

Results in Table 7 shows the effect of spraying foliar fertilizer and antioxidant on the tree yield of apricot, var. Zaghenia. Foliar fertilizer significantly affected the trait where spraying 1.5g.L^{-1} (F1) produced 16.52 k.$tree^{-1}$ while the control treatment (F0) gave 14.95 kg.$tree^{-1}$. The treatments of antioxidants also significantly affected the tree yield. The treatment of spraying ascorbic acid at the concentration 1000 mg.L^{-1} (A2) was superior giving the 20.17 kg. $tree^{-1}$ compared to the control treatment that gave 13.50 kg.$tree^{-1}$. Propyl Gallate also affected the tree yield significantly. The concentration 300 mg.L^{-1}(P2) produced 14.67 kg.$tree^{-1}$ surpassing the control treatment giving 13.50 kg.$tree^{-1}$.

The reason behind these results belongs to the superiority of thetreatments in the previous traits whether vegetative such as leaf area, chlorophyll content, and carbohydrate amount (Tables 2, 3, and 4 respectively), or fruit traits such as fruit set percentage and fruit size (Tables 5 and 6 respectively). The significant superiority whether affected by the foliar fertilizer or by antioxidant or both, it would reflect on the tree yield, it should be noted that the tree yield was recorded based on the weights of the harvested fruits for each tree separately. Propyl Gallate increased the yield remarkably compared to the control treatment may be due to, as previously mentioned, it is a safe antioxidant alleviates the oxidative damages and enhances the tree resistance against varied stresses and consequently preserves the fruits until the harvesting time (Feixu *et al.*, 2012).

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