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Effect of Foliar Spraying of Chelated Iron, Nutrient Solution Prosol and the Amino Acid Proline on the Growth of Pomegranate Seedlings (*Punica granatum* L.) cv. Salimi

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ABSTRACT

This study was conducted in the wooden canopy of the Department of Horticulture and Landscape Engineering, College of Agriculture, University of Anbar for the period from April to January 2021 to study the effect of foliar spraying with chelated iron, the nutrient solution prosol and the amino acid proline in the growth of pomegranate seedlings Salimi cultivar. The addition of chelated iron F_2 (60 mg/l) had a significant effect on leaf area (11.155 cm^2), rate of increase in stem diameter (4.291 mm), root length (74,851 cm), chlorophyll (45.890 mg/g mushy weight), potassium (1.620%) and iron (613.507 ppm). The nutrient solution Prosol showed that treatment S_2 (100 mg/l) was significantly superior to the increase in leaf area (10,711 cm^2), the rate of increase in stem diameter (3.665 mm), root length (65.807 cm), chlorophyll (41.834 mg/g mushy weight), potassium (1.719%), and iron (574.960 ppm). Foliar spraying with the amino acid proline showed the superiority of treatment P_2 (200 mg/l) significantly increased in each of the leaf area (10.428 cm^2), the rate of increase in stem diameter (3.461 mm), root length (64.037 cm), chlorophyll (42.123 mg/g mushy weight), potassium (1.607%) and iron (547.555 ppm). As for the binary interaction between the study factors: chelated iron and the nutrient solution prosol, and the binary interaction between chelated iron and the amino acid proline, as well as the bilateral interaction between the nutrient solution prosol and the amino acid proline, it had significant effect on most of the studied traits as leaf area (12.333 cm^2), growth rate in stem diameter (4.696 mm), root length (80,000 cm), chlorophyll (48.453 mg/g mushy weight), potassium (1.798%), iron (666.240 ppm).

Key words: Pomegranate, foliar spray, chelated iron, prosol nutrient solution, proline amino acid

INTRODUCTION

Pomegranate, with its name (*Punica granatum* L.) and its relative to the pomegranate family (Punicaceae), is one of the economically important fruit trees in the tropics and sub-tropics (Shaygannia *et al.*, 2016). Because the tree is highly adaptable to a wide range of climates and soil conditions, it is grown in many different geographical areas, including the Mediterranean basin (Singh *et al.*, 2020). All plants need micro-nutrients in small quantities compared to the main nutrients, and the deficiency of one or more of these nutrients negatively affects the vegetative and root characteristics of these plants (Mondal and Bose, 2019). The system of enzymes that enters into the respiration process has a role in maintaining green matter and representing amino acids and chloroplasts, in addition to its active role in respiration and photosynthesis (Karthika *et al.*, 2018). Foliar spraying with prosol is of great importance in improving the vegetative, root and chemical characteristics of the plant because it contains the main nutrients (NPK) in addition to a group of important secondary elements that the plant needs. It plays a major role in protein formation and increasing chlorophyll rates, as well as the role of major and minor elements that prosol provides in increasing the concentration of auxins and gibberellins, which increases the rates of cell division and elongation, in addition to increasing the surface area of the leaf (Al-Shareefi and Kadhim, 2019). Proline is an amino acid that helps to maintain vegetation cover under conditions of severe salt stress, and spraying with proline reduces the effects of stress and salinity damage and helps to build proteins (Singh *et al.*, 2014). Based on what has been mentioned, this study aimed at: (1) shortening the period between the growths of seedlings and reaching the flowering stage, by obtaining strong and branched seedlings in the shortest period at the stage of flowering and fruiting,

(2) determining the best concentration for treatment with chelated iron, prosol nutrient solution, and proline amino acid, and the interaction between them to obtain a strong structure for pomegranate seedlings by improving the efficiency of root and vegetative growth and increasing the content of nutrients and carbohydrates and (3) studying the interaction of the study factors and their effect on the vegetative, root and chemical characteristics of pomegranate seedlings in cultivar Salimi.

MATERIALS AND METHODS

The study was carried out on one-year-old pomegranate seedlings cultivar Selimi planted in 5 kg plastic bags and treated by spraying the shoots with chelated iron at three levels (0, 30 and 60 mg/l) and three levels of the nutrient solution prosol (0, 50 and 100 mg/l) and three levels of proline (0, 100 and 200 mg/l). The seedlings were sprayed until full wetness on the following dates 9/4/2021, 9/5/2021, 9/6/2021 and 9/9/2021. A factorial experiment with three factors and three replications was carried out using a completely randomized sector design, with three sectors. Each sector contained (27) treatments and three replicates, and each replicate represented one seedling for each experimental unit, meaning a total of (81) seedlings for all sectors. The results were analyzed according to the analysis of the variance, and the averages were compared using the least significant difference (L. S. D) test at a level of significance of 5%, and the statistical program Genstat was used in the process of data analysis.

The study included a factorial experiment with three factors: (a) chelated iron at a concentration of 0, 30 and 60 mg/l symbolized as F_0, F_1 and F_2; (b) Prosol nutrient solution with a concentration of 0, 50 and 100 mg/l symbolized as S_0, S_1 and S_2; and (c) the amino acid proline at a concentration of (0, 100 and 200 mg/l) symbolized as P_0, P_1 and P_2.

Data were recorded on (1) leaf area in cm^2 (average area of a full-wide sheet of paper was calculated using the digitizer program by taking 10 sheets of paper and photographing them with the scanner and using an indication of the length of the distance as if it was 10 cm in a coloured font, then the image was transferred to the program on the computer, as the program determined the boundaries of the plant part, provided that it did not touch the boundaries of the leaf on which it was installed to calculate the total area of the specified part, and then take the average leaf area; (2) the rate of increase in the diameter of the stem in mm (the diameter of the main stem was calculated at a height of 5-10 cm from the surface of the soil of the bag using the foot vernier at the beginning and end of the experiment. The rate of increase in the diameter of the stem was measured for one replicate, then according to the rate increment per transaction); (3) root length in cm (the root length was calculated from the area of contact with the stem to its end using a metric tape); (4) chlorophyll (it was estimated according to the Qiu *et al.*, 2016); (5) potassium content in leaves (the percentage of potassium in leaves was estimated by taking 5 ml of the digest extract and measuring in Flame Photometer at a wavelength of 766 nm (Piper, 2019) and (6) iron content in leaves (using a spectrophotometer, Latimer, 2016).

RESULTS AND DISCUSSION

The spraying treatment with chelated iron was significantly superior for the leaf area, as treatment F_2 recorded the highest leaf area of 11.155 cm^2, followed by treatment F_1, which amounted to 9.815 cm^2, while treatment F_0 gave the lowest value of 8.930 cm^2 (Table 1). While spraying with the nutrient solution Prosol significantly increased the leaf area, especially in treatment S_2, which amounted to 10,711 cm^2 compared to the control treatment S_0, which gave the lowest value of 8.967 cm^2.

As for the amino acid proline, it had a significant effect on increasing the leaf area. Treatment P_2 was characterized by giving the largest value of 10,428 cm^2 and did not differ significantly from treatment P_1, which amounted to 10.149 cm^2, which outperformed the control treatment P_0 as it reached 9.323 cm^2.

The bilateral interaction between the chelated iron and the nutrient solution prosol had a significant effect, as the treatment F_2S_2 gave the highest value with leaf area amounting to 12,084 cm^2 compared to the comparison treatment F_0S_0, which had a value of 7.653 cm^2.

Table 1. Effect of spraying chelated iron, prosol nutrient solution and proline amino acid and their interactions on leaf area (cm^2)

Factor F	Factor S	Factor P			F × S
		P_0	P_1	P_2	
F_0	S_0	7.526	7.680	7.753	7.653
	S_1	8.746	9.333	9.600	9.226
	S_2	9.736	9.813	10.183	9.911
F_1	S_0	8.126	9.596	9.860	9.194
	S_1	9.013	10.620	10.700	10.111
	S_2	9.293	10.036	11.090	10.140
F_2	S_0	8.276	10.663	11.220	10.053
	S_1	11.386	11.480	11.116	11.327
	S_2	11.800	12.120	12.333	12.084
Rate F					
F × P	F_0	8.670	8.942	9.178	8.930
	F_1	8.811	10.084	10.550	9.815
	F_2	10.4878	11.4211	11.556	11.155
Rate S					
S × P	S_0	7.976	9.313	9.611	8.967
	S_1	9.715	10.477	10.472	10.221
	S_2	10.276	10.656	11.202	10.711
Rate P		9.323	10.149	10.428	
LSD (P=0.05)					
F × S × P	S × P	F × P	F × S	P	S	F
0.841	0.485	0.485	0.485	0.280	0.280	0.280

The results showed that the binary interaction between the two factors of the study, chelated iron and proline, had a significant effect, as the F_2P_2 treatment achieved the highest value for leaf area amounting to 11,556 cm^2 compared with the control treatment, which gave the lowest value of 8.670 cm^2.

It is noted from the same table that the binary interaction between the nutrient solution prosol and the amino acid proline was significantly superior to the leaf area if the S_2P_2 treatment achieved the highest value of 11,202 cm^2 compared to the comparison treatment, which amounted to 7.976 cm^2. As for the triple interference, the treatment $F_2S_2P_2$ outperformed the leaf area, which amounted to 12.333 cm^2 compared to the control treatment $F_0S_0P_0$, which amounted to 7.526 cm^2.

Spraying with chelated iron led to a significant increase in the average stem diameter, as treatment F_2 (60 mg/l) was significantly superior by attaining the highest value of 4.291 mm, followed by treatment F_1, which in turn was significantly superior to the treatment F_0, which recorded the lowest rate of increase in stem diameter, which was 2.469 mm (Table 2). Spraying with the nutrient solution prosol led to a significant increase in stem diameter, as treatment S_2 (100 mg/l) outperformed and gave the highest value for the rate of increase in stem diameter amounting to 3.665 mm, followed by treatment S_1, which in turn was significantly superior to the comparison treatment S_0, which recorded the lowest value of 3.086 mm. It is clear from the results of Table 2 that spraying with the amino acid proline P_2 (200 mg/l) led to a significant superiority over the other two treatments and gave the highest rate of increase in stem diameter amounting to 3.461 mm, followed by treatment P_1, which in turn was significantly superior to the control treatment, which recorded the lowest rate of 3.297 mm. As for the bilateral interaction between chelated iron and prosol nutrient solution (60+100 mg/l), treatment F_2S_2 achieved the highest rate of stem diameter of 4.604 mm, while treatment F_0S_0 recorded the lowest value of stem diameter of 2.270 mm. The bilateral interaction between chelated iron and the amino acid proline (60+200 mg/l) significantly affected stem diameter, as F_2P_2 treatment achieved the highest rate of 4.365 mm, while treatment F_0P_0 recorded the lowest rate of increase in stem diameter of 2.411 mm. As for the bilateral interaction between the nutrient solution prosol and the amino acid proline, no significant differences appeared in this

Table 2. Effect of spraying chelated iron, prosol and amino acid proline and their interactions on the rate of increase in stem diameter (mm)

Factor F	Factor S	Factor P			F × S
		P_0	P_1	P_2	
F_0	S_0	2.243	2.270	2.296	2.270
	S_1	2.356	2.420	2.506	2.427
	S_2	2.633	2.703	2.796	2.711
F_1	S_0	2.926	3.020	3.190	3.045
	S_1	3.303	3.403	3.486	3.397
	S_2	3.576	3.680	3.783	3.680
F_2	S_0	3.870	3.966	3.993	3.943
	S_1	4.253	4.320	4.406	4.326
	S_2	4.510	4.606	4.696	4.604
Rate F					
F × P	F_0	2.411	2.464	2.533	2.469
	F_1	3.268	3.367	3.486	3.374
	F_2	4.211	4.297	4.365	4.291
Rate S					
S × P	S_0	3.013	3.085	3.160	3.086
	S_1	3.304	3.381	3.466	3.384
	S_2	3.573	3.663	3.758	3.665
Rate P		3.297	3.376	3.461	
LSD (P=0.05)					
F × S × P	S × P	F × P	F × S	P	S	F
0.038	NS	0.022	0.022	0.012	0.012	0.012

characteristic. As for the combined triple interaction $F_2S_2P_2$ (60+100+200 mg/l) it significantly affected this trait achieving the highest value of 4.696 mm, as treatment $F_0S_0P_0$ recorded the lowest rate of stem diameter (2.243 mm).

Spraying with chelating iron had a significant effect on pomegranate seedlings, as treatment F_2 excelled by giving it the highest value of root length amounting to 74.851 cm, and in contrast, treatment F_0 recorded the lowest value of root length amounting to 52.888 cm (Table 3). As for spraying the seedlings with the nutrient solution prosol, treatment S_2 showed a significant superiority by giving it the highest percentage of 65.807 cm. It indicated that there were significant differences between the two treatments S_1 and S_0, while the lowest value was 58,233 cm in treatment S_0. It was noted from the results that spraying with the amino acid proline had a significant effect on this trait, especially when treatment P_2 amounted to 64.037 cm, was superior to the other two treatments, followed by treatment P_1, which amounted to 61.329, which was significantly superior to the comparison treatment P_0, which recorded the lowest value of 59. 711 cm. The interaction of spraying with chelated iron and the nutrient solution prosol F_2S_2 (60+100 mg/l) showed its significant effect, as the highest value of root length was 78.777 cm. Contrarily, treatment F_0S_0 recorded the lowest value of 46.111 cm. As for the interaction between chelated iron and the amino acid proline (60+200 mg/l), there were no significant differences for this character. The effect of the interaction between the nutrient solution prosol and the amino acid proline S_2P_2 at a concentration of (100+200 mg/l) achieved largest root length of 68.777 cm compared to treatment S_0P_1 which reached only 56.811 cm. As for the triple interaction $F_2S_2P_2$ (60+100+200 mg/l), it had a significant effect on root length as it reached 80,000 cm giving it the largest root length compared to the comparison treatment which amounted to the comparison factor which amounted to 43.666 cm.

Spraying with chelated iron led to a significant increase in the total chlorophyll content in the leaves, especially treatment F_2 (60 mg/l) which amounted to 45,890 mg/g mushy weight, which was significantly superior to the other two treatments followed by treatment F_1 (30 mg/l), which was significantly superior to the control treatment F_0 (Table 4). It recorded the lowest content of chlorophyll in leaves, which amounted to 35,762 mg/g mushy weight. Spraying the nutrient solution prosol had a significant effect especially the treatment S_2, which amounted to 43.195 mg/g mushy weight, which was significantly superior to all spraying treatments with the nutrient solution prosol, while the comparison treatment recorded the lowest value of 38.320 mg/g fresh weight. As for the spraying of the amino acid proline, it led to a significant increase in the chlorophyll content in the leaves, as the P_2 treatment achieved the highest value of 42.123 mg/g mushy weight, while the comparison treatment gave the lowest value, which was 39.997 mg/g mushy weight. The results showed the bilateral interaction between chelated iron and the nutrient solution prosol, a significant effect on the chlorophyll content of leaves, as the F_2S_2 treatment was superior and gave the highest value amounting to 47.457 mg/g fresh weight. In contrast, the comparison treatment recorded the lowest value of 30,864 mg/g mushy weight. It was also shown from the same table that the chlorophyll content in the leaves had a significant effect on the interaction treatment between chelated iron

Table 3. Effect of spraying chelated iron, prosol nutrient solution and proline amino acid and the interactions between them on root length (cm)

Factor F	Factor S	Factor P			F × S
		P_0	P_1	P_2	
F_0	S_0	43.666	45.000	49.666	46.111
	S_1	50.666	54.000	56.333	53.666
	S_2	58.333	58.000	60.333	58.888
F_1	S_0	62.333	53.433	56.333	57.366
	S_1	51.000	55.333	58.333	54.888
	S_2	52.733	60.533	66.000	59.755
F_2	S_0	68.666	72.000	73.000	71.222
	S_1	72.333	75.000	76.333	74.555
	S_2	77.666	78.666	80.000	78.777
Rate F					
F × P	F_0	50.888	52.333	55.444	52.888
	F_1	55.355	56.433	60.222	57.337
	F_2	72.888	75.222	76.444	74.851
Rate S					
S × P	S_0	58.222	56.811	59.666	58.233
	S_1	58.000	61.444	63.666	61.037
	S_2	62.911	65.733	68.777	65.807
Rate P		59.711	61.329	64.037	
LSD (P=0.05)					
F × S × P	S × P	F × P	F × S	P	S	F
2.377	1.372	N.S	1.372	0.792	0.792	0.792

Table 4. Effect of foliar spraying with chelated iron, prosol nutrient solution and proline amino acid and their interactions on chlorophyll content in leaves (mg/g mushy weight)

Factor F	Factor S	Factor P			F × S
		P_0	P_1	P_2	
F_0	S_0	26.033	31.920	34.640	30.864
	S_1	36.533	37.866	38.726	37.708
	S_2	38.500	38.520	39.120	38.713
F_1	S_0	38.666	39.906	40.500	39.691
	S_1	41.666	41.720	42.573	41.986
	S_2	42.573	43.760	43.913	43.415
F_2	S_0	43.986	44.473	44.760	44.406
	S_1	45.220	45.780	46.420	45.806
	S_2	46.800	47.120	48.453	47.457
Rate F					
F × P	F_0	33.688	36.102	37.495	35.762
	F_1	40.968	41.795	42.328	41.697
	F_2	45.335	45.791	46.544	45.890
Rate S					
S × P	S_0	36.228	38.766	39.966	38.320
	S_1	41.140	41.788	42.573	41.834
	S_2	42.624	43.133	43.828	43.195
Rate P		39.997	41.229	42.123	
LSD (P=0.05)					
F × S × P	S × P	F × P	F × S	P	S	F
1.599	0.923	0.923	0.923	0.533	0.533	0.533

Table 5. Effect of foliar spraying with chelated iron prosol nutrient solution and proline amino acid and their interactions on potassium content in leaves (%)

Factor F	Factor S	Factor P			F × S
		P_0	P_1	P_2	
F_0	S_0	1.169	1.239	1.310	1.239
	S_1	1.272	1.378	1.350	1.333
	S_2	1.450	1.718	1.745	1.638
F_1	S_0	1.310	1.330	1.450	1.363
	S_1	1.450	1.718	1.745	1.638
	S_2	1.718	1.745	1.782	1.748
F_2	S_0	1.349	1.370	1.493	1.404
	S_1	1.493	1.770	1.788	1.684
	S_2	1.770	1.746	1.798	1.771
Rate F					
F × P	F_0	1.297	1.445	1.468	1.403
	F_1	1.493	1.598	1.659	1.583
	F_2	1.537	1.628	1.693	1.620
Rate S					
S × P	S_0	1.276	1.313	1.418	1.335
	S_1	1.405	1.622	1.628	1.552
	S_2	1.646	1.736	1.775	1.719
Rate P		1.442	1.557	1.607	
LSD (P=0.05)					
F × S × P	S × P	F × P	F × S	P	S	F
0.135	0.078	N.S	0.078	0.045	0.045	0.045

and the amino acid proline, as F_2P_2 recorded the highest value of 46.544 mg/g mushy weight, while the comparison treatment F_0P_0 recorded the lowest content of chlorophyll in leaves as 33,688 mg/g weight. As for the bilateral interaction between the nutrient solution prosol and the amino acid proline, it showed a significant effect, especially the S_2P_2 treatment, which gave the highest value of 43.828 mg/g mushy weight. In contrast, the comparison treatment S_0P_0 recorded the lowest value, which was 36,228 mg/g fresh weight. As for the triple interaction of the study factors, the treatment $F_2S_2P_2$ (60+100+200 mg/l) achieved the highest value of 48,453 mg/g mushy weight, while the comparison treatment $F_0S_0P_0$ recorded the lowest value of 26,033 mg/g mushy weight.

It is clear from the results in Table 5 that there were significant differences in the potassium content in the leaves when spraying with chelated iron, especially in treatment F_2, which recorded the highest percentage of 1.620, which did not differ significantly from treatment F_1 (Table 5) which amounted to 1.583% compared to F_0, which achieved the lowest potassium content in leaves amounted to 1.403%. The results of the same table indicate the effect of treatment with the nutrient solution prosol in increasing the potassium content in the leaves, which increased significantly by increasing the spray levels, reaching 1.335, 1.552 and 1.7199%, respectively, for the levels S_0, S_1, S_2 sequentially. The table showed that there were significant differences as a result of spraying with the amino acid proline, as the potassium content in the leaves increased in treatment P_2, which recorded a percentage of 1.607, followed by treatment P_1, which amounted to 1.557%, while the comparison treatment recorded the lowest percentage of 1.442. As for the bilateral interaction between the chelated iron and the nutrient solution prosol, it significantly affected this trait, especially the F_2S_2 treatment, which achieved the highest potassium percentage in the leaves, reaching 1.771. On the other hand, the comparison treatment recorded the lowest percentage, 1.239. As for the bilateral interaction between chelated iron and the amino acid proline, no significant differences appeared in this trait. As for the bilateral interaction between the nutrient solution prosol and the amino acid proline, it achieved a significant superiority between the treatments, as the S_2P_2 treatment recorded the highest percentage of 1.775, while the control treatment recorded the lowest

percentage of 1.276. The triple interaction between the chelated iron and the nutrient solution prosol and the amino acid proline had a significant effect between the treatments at a concentration of (60+100+200 mg/l), if the $F_2S_2P_2$ treatment achieved the highest percentage of 1.798, while the comparison treatment $F_0S_0P_0$ achieved the lowest percentage of 1.169.

The results in Table 6 show that the spraying with chelated iron had a significant effect on the iron content in the leaves, where the treatment F_2 achieved the highest value of iron content in the leaves, which amounted to 613.507 ppm, followed by the treatment F_1, which amounted to 531.588 ppm. The comparison treatment F_0 recorded the lowest value for iron content in leaves as 460,090 ppm. The results showed a significant effect of the nutrient solution prosol on the iron content of leaves, as S_2 showed the highest rate of the trait amounting to 574,960 ppm, which was significantly superior to all treatments. The control treatment S_0 recorded the lowest value, which was 496,167 ppm. It was also noted from Table 6 that there was a significant effect when spraying with the amino acid proline, as the treatment P_2 achieved the highest iron content in the leaves, which amounted to 547.555 ppm, superior to the other two treatments, followed by the treatment P_1, which in turn outperformed the control treatment P_0, which recorded the lowest value for iron content in the leaves as 519.275 ppm. As for the bilateral interaction between the chelated iron and the nutrient solution prosol, it significantly affected as the F_2S_2 treatment recorded the highest value of 659.926 ppm. In contrast, the comparison treatment F_0S_0 recorded the lowest percentage of 432.011 ppm. The interaction between chelated iron and the amino acid proline had a significant effect on the iron content of leaves, as the F_2P_2 treatment achieved the highest value of 628.524 ppm, and on the other hand, the comparison treatment was 440,533 ppm. It was noted from the bilateral interaction between the nutrient solution prosol and the amino acid proline that no significant differences appeared in this trait. As for the common triple interaction between the factors of the study, it showed a significant effect in this trait, especially the $F_2S_2P_2$ treatment, which recorded the highest

Table 6. Effect of foliar spraying with chelated iron, prosol nutrient solution and proline amino acid and their interactions on the iron content in leaves (ppm)

Factor F	Factor S	Factor P			F × S
		P_0	P_1	P_2	
F_0	S_0	404.150	441.516	450.366	432.011
	S_1	443.483	461.183	462.166	455.611
	S_2	473.966	496.583	507.400	492.650
F_1	S_0	491.053	499.533	506.416	499.001
	S_1	509.366	525.100	535.916	523.461
	S_2	569.350	567.403	580.160	572.304
F_2	S_0	546.256	553.916	572.300	557.491
	S_1	593.933	628.350	647.033	623.105
	S_2	641.923	671.616	666.240	659.926
Rate F					
F × P	F_0	440.533	466.427	473.311	460.090
	F_1	523.256	530.678	540.831	531.588
	F_2	594.0378	617.9611	628.5244	613.507
Rate S					
S × P	S_0	480.486	498.322	509.694	496.167
	S_1	515.594	538.211	548.372	534.059
	S_2	561.746	578.534	584.600	574.960
Rate P		519.275	538.355	547.555	
LSD (P=0.05)					
F × S × P	S × P	F × P	F × S	P	S	F
16.367	NS	9.449	9.449	5.455	5.455	5.455

value of 666.240 ppm, whereas in control treatment $F_0S_0P_0$ recorded the lowest value for iron content in the leaves, which was 404.150 ppm.

The reason for the increase in leaf area, stem diameter, root length, chlorophyll, potassium, and iron is attributed to the role of chelated iron, which enters the formation of cytochromes important in the process of photosynthesis and respiration, as it was found that 80% of the total iron is present in chloroplasts, and this explains its importance in the process of photosynthesis, as well as its role in building chlorophyll, although it does not enter into its composition (Rout and Sahoo, 2015). The reason for the increase in the rate of stem diameter may be due to the role of iron in many biological processes within the plant, such as the synthesis of amino acids, proteins, and enzymes that promote cell division and elongation, thus increasing plant tissues, which led to an increase in the activity of the cambium layer in pear trees (Abd-El-Latif *et al.*, 2020).

Iron also plays an important role in the synthesis of the nitrogenase enzyme. This helps in fixing nitrogen in addition to its regulatory role for oxidation and reduction enzymes and its ability to lose and gain electrons and its entry into the installation of some carrier enzymes that control the

mechanism of respiration (Schmidt *et al.,* 2020). The reason for the increase in the aforementioned characteristics when spraying with the nutrient solution prosol is due to the macronutrients it contains (NPK) and micronutrients (Fe, Mn, (Zn), which have an important role in the biological processes inside the plant. It also contributes to stimulating the process of photosynthesis, division processes and cellular elongation, which lead to the vegetative growth that increases the leaf area (Hassan, 2017). The reason for the increase in the average stem diameter is that the nitrogen in the prosol is mainly included in the synthesis of nucleic acids, proteins and chlorophyll, which lead to an increase in the vegetative characteristics of seedlings, including stem diameter (Al-Himdany and AL-Ahbaby, 2019). The reason for the increase in potassium in leaves may be due to it being one of the monovalent positive ions that plants need in large quantities, although it does not enter into an organic compound and plays an auxiliary role in many vital processes such as photosynthesis, protein formation, and carbohydrate metabolism and the representation of the mechanism of opening and closing the stomata (Barker and Pilbeam, 2015). It may be the reason for the increase in iron concentration in the leaves due to the increase in vegetative growth and the consequent increase in the absorption of these nutrients. Elements meet the needs of the plant, and this may be due to their role in many important processes (Kobayashi *et al.,* 2019). The role of the amino acid proline is due to increasing the above-mentioned characteristics through its ability to activate vital activities, especially the processes of division and elongation of plant cells, in addition to its important role in increasing the activity of enzymes that work to analyze organic acids, as well as its importance in building nucleic acids and metabolic processes (Hildebrandt *et al.,* 2015). Proline has a role in the process of osmotic regulation inside the plant cell between the vacuole and the cytoplasm, so that proline increases in the cytoplasm and harmful ions accumulate in the vacuole and this pushes proline to accumulate in the cytoplasm to create a state of balance to maintain the swelling of cells, which in turn leads to a reduction in the water effort of the cell and an increase in the capacity of the cell on the withdrawal of water and nutrients dissolved in it from the soil and thus increasing the vegetative and root system of the plant (Ghosh *et al.,* 2022). The high percentage of chlorophyll in the leaves when spraying with proline is attributed to the nitrogen produced by the amino acid, which enters the composition of chlorophyll in addition to being considered the basic building block in the installation and construction of amino acids necessary for building chloroplasts and thus increasing chlorophyll content in leaves (Kolukisaoglu, 2020).

CONCLUSION

Foliar spraying with chelated iron Fe significantly affected all studied traits, especially spraying with F_2 treatment (60 mg/ g). The growth characteristics of pomegranate seedlings increased by increasing the levels of spraying with the nutrient solution prosol, especially the S_2 treatment. Similarly, a significant increase occurred when spraying with the amino acid proline, especially the P_2 treatment. All these recorded a significant increase in all characteristics of vegetative and root growth and the content of mineral elements in leaves and branches.

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