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ORIGINAL ARTICLE

EFFECT OF IRON TREATMENT AND FERTILIZER OF HIGH PHOSPHOROUS (N.P.K) ON VEGETATIVE AND FLOWERING GROWTH OF LALLA ABBAS PLANT, *MIRABILIS JALABA* L.

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Abstract: The study was carried out at the College of Agriculture, Agricultural Research Station, University of Basra, on Lalla Abbas plants. The seeds were sown in an anvil with a diameter of 10 cm in soil consisting of peat moss and loam soil at a ratio of 2:1 in a canopy covered with saran wrap. The anvils were covered with a layer of nylon until the germination process was completed. After a month of planting, the plants were taken care of by watering and fertilizing with NPK at the rate of 1 g per anvil per month. After the growth of the plants and their height of 10 cm, the plants were treated by spraying with iron (0, 0.5, 1.5) g l^{-1}, as well as NPK fertilizer high in phosphorous (0, 1.5, 3 g l^{-1}) and the addition process was repeated one month after the first treatment. The results of the study showed the effect of iron and high-phosphorous compound fertilizer on the vegetative characteristics of the plant of Lalla Abbas, as the treatment with iron 1.5 g l^{-1} was far and away the best of the treatments and resulted in the greatest growth in plant height, stem diameter, number of leaves, bulb weight, and number of inflorescences as it reached (55.49 cm, 2.09 mm, 125 leaves, 113.21 g, and 22.67 flowers), respectively, while control treatment gave a lowest rates for the same traits. The compound fertilizer of the 3 gl^{-1} treatment also affected among all other treatments, and statistically significant above-average was recorded for plant height, stem diameter, number of leaves, bulb weight and number of inflorescences, which reached 53.47 cm, 2.16 mm, 127.33 leaves, 116.56 g and 23.33 inflorescences. Sequentially, the comparison treatment recorded the lowest rates for the same studied traits. As for the interaction between iron and compound fertilizer, the interaction between iron 1.5 g l^{-1} and compound fertilizer 3 g l^{-1} recorded the highest rates for all studied traits. The results of protein pattern in leaves also showed that the treatments affected the gene expression process of Lalla Abbas plants and caused the emergence of a new protein package, indicating that the study treatments stimulated the cells to manufacture new proteins that support indicators of growth and development in the treated plants.

Key words: Iron, Compound fertilizer, Phosphorus, Vegetative growth, Flowering.

Cite this article

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1. Introduction

The plant of Lalla Abbas, *Mirabilis jalaba* L., a member of the Nyetaginaceae family. It called the night plant or the four o'clock plant because its flowers bloom from four o'clock in the evening until the next morning. It is a small shrub of perennial flowering plants; its height ranges from half a meter to one metre. The plant continues to bloom as long as it constantly finds water. It is found growing wild in the western region within orchids; a medicinal laxative substance is extracted from its tuberous roots (enlarged). It reproduces by tuberous roots or seeds, of which a large amount can be collected from one plant, grows easily and relatively quickly either inside the nursery at any time of the year or outside during the abundant spring season. Branching and succeeding in all lands, it can be planted as a flowering fence. The flowers are funnel-shaped and multi-colored, including those tilted toward violet or yellow; the red-purple flowers have a fragrant smell. Plants have been used for medicinal and health purposes

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for thousands of years. There are approximately 250,000 plant species, the highest number of species on the planet [Chalabi and Al-Khayyat (2013)].

Iron is one of the important elements in plant growth through its influence on many vital processes through its activation of enzymatic processes within the plant, and iron has physiological importance in the process of chlorophyll formation in the plant as it enters as a catalyst and stimulant in the reactions of the formation of green pigments in a chemical reaction leading to the formation of the chlorophyll molecule. Phosphorous is one of the main elements in plant nutrition, as it contributes to plant development, cellular growth and division, and seed production. After nitrogen and potassium, phosphorus is the plant's third most essential nutrient, and its availability in the soil throughout the stages of plant growth, particularly during the branching and flowering stage is crucial for most agricultural crops is necessary to obtain good productivity. Also, the element phosphorus causes the improvement of the characteristics of vegetative and flowering growth and the carbohydrate content of the leaves [Ali (2012), Al-Taher (2016), Al-Hasany *et al*. (2020)]. Alshewailly and Alpresem's (2019) study also concluded that the proteomic analysis method is efficient in determining the nature of the effect on the plant gene expression process due to various environmental factors such as fertilization and other environmental conditions.

Foliar fertilization depends on supplying the plant with the necessary nutrients through spraying on the shoot of the plant, which has the ability to absorb these elements through the stomatal openings spread on the upper and lower leaf surfaces [AL-Taher *et al*. (2020)]. Foliar fertilization leads to plant protection, allowing you to grow it properly and get rid of the manifestations of deficiency of microelements such as yellowing leaves, spotting and poor growth, as foliar fertilization is one of the easiest and most appropriate ways to absorb the elements. It is worth noting that the absorption of nutrients added through foliar fertilization takes place very quickly and the plants respond within 2–7 days, depending on the type and nature of the plant and the severity of the apparent deficiency on the plant. Foliar fertilization also ensures the speedy correction of plant-feeding disorders and the elimination of manifestations of deficiency of microelements such as yellowing leaves, spotting and poor growth [Smolen (2012), Karthikeyan *et al*. (2020)].

The aim of this study was to examine the connection between iron and NPK fertilizer high in phosphorus on the vegetative, flowering and protein profile of Lalla Abbas plant.

2. Materials and Methods

The study was carried out at the University of Basra's College of Agriculture's Agricultural Research Station, on plants from Lalla Abbas. Seeds were sown by one seed in each anvil with a diameter of 10 cm and soil consisting of peat moss and loam soil at a ratio of 2:1 in a canopy covered with a saran blanket. The anvils were covered with a layer of nylon until the germination process complete. After a month of planting, the plants were taken care of by watering and fertilizing with NPK at the rate of 1 g per anvil per month and after the growth of the plants and their height of 10 cm, the plants were treated by spraying with iron (0, 0.5, 1.5) gL^{-1}, as well as NPK fertilizer high in phosphorous (0, 1.5, 3 gL^{-1}) and the addition process was repeated one month after the first treatment. Lalla Abbas is considered one of the perennial flowering plants, as the research continued for two seasons, the vegetative growth season and the flowering season. In the second season, the plants were transferred to anvils with a diameter of 20 cm.

The following traits were studied:

2.1 Plant height (cm)

Take a tape measure and measure the plant's height from the soil's surface to its growing tip.

2.2 Stem diameter (mm)

It was measured for each plant and then extracted the rate for each parameter using the Digital Vernier Calipers at a height of 5 cm above the soil surface.

2.3 Leaves number

The total leaves number for each of the plants in each experimental unit was counted and its rate was recorded.

2.4 Bulbs weight (g)

The weight of the total bulbs was calculated using a sensitive scale for each of the plants in each experimental unit and its average was recorded.

2.5 The number of inflorescences per plant

The average number of flowering inflorescences per plant in each experimental unit was determined.

2.6 Florets number in inflorescence

These were obtained according to the number of florets for each selected plants from each unit and record their average.

2.7 Leaves content of carotenoids (mg 100 g fresh^{-1})

Carotenoids in leaves were estimated according to a method described by Abbas and Muhsin (1992). As it was extracted by acetone 80%, the dye was determined by a spectrophotometer, and the measurement was at a wavelength of 480 nm.

2.8 Total chlorophyll leaves content (mg 100 g^{-1})

The chlorophyll pigment in the green leaves was estimated by taking 0.5 gm of the leaves for each treatment, according to the method of Al-Najjar *et al*. (2021). 10 ml of 80% diluted acetone was added to the sample and the leaves were mashed with a ceramic mortar. The sample was then placed in a centrifuge for 10 minutes, after which the liquid was taken. The absorbance was estimated by a spectrophotometer at wavelengths of 645 and 665 nm and then the amount of total chlorophyll was estimated.

2.9 Leaf carbohydrate content (mg 100 g^{-1})

It was estimated by the Modification of the Phenol-Sulphric acid Colorimetric Method prepared by Dobois *et al*. (1956).

2.10 Leaf prototype

The leaves were collected as a sample. We used a freeze-dryer (lyophilization technique) set to -26^{o}C to dry the samples. The samples were processed for protein extraction using the protocol outlined by Al-Najjar *et al*. (2021). SDS denaturants were used in the slab electrophoresis technique to facilitate protein migration on a polyacrylamide gel, as described by Bavei *et al*. (2011). The Promega markers were used to estimate and plot the molecular weights of the proteins using a specialized computer program called PhotoCapt Mw (17 version). The following numbers correspond to each individual transaction:

1-Marker, 2-control, 3- Fe, 1.5g.L^{-1}, 4- NPK, 3g.L^{-1}, 5- Control of interaction, 6- Intraction, Fe 1.5 g.L^{-1} +NPK 3 g.L^{-1}.

2.11 Statistical Analysis

Factorial experiment with completely randomized sectors was used for the design of this study and analysis of variance was used to check for statistically significant differences in the characteristics measured by the Genstat software. The modified least significant difference test (D.S.L.) was used to analyze the means and determine statistical significance at the 0.05 level **.**

3. Results and Discussion

3.1 Plant height average (cm)

Table 1 showed the effect of iron treatment and high-phosphorous compound fertilizer on the rate of plant height at Lalla Abbas, as the iron treatment of 1.5 g/l exceeded the effectiveness of all other treatments by a large margin and recorded a highest average of 55.49 cm, while control treatment recorded a lowest rate of 43.50 cm.

The compound fertilizer also had a significant effect with 3 g/l excelled over the rest of the treatments and recorded the highest significant rate of 53.47 cm, while the comparison treatment recorded the lowest rate of 45.48 cm.

As for the interaction between iron and the compound fertilizer, the interaction between iron 1.5 g l1 and the compound fertilizer 3 g l^{-1} recorded the highest rate of plant height, reaching 59.97 cm, with a significant difference, while the interference for the comparison treatment recorded the lowest rate of 40.35 cm.

3.2 Stem diameter (mm)

According to Table 2, the average stem diameter of the Lalla Abbas plant increased with iron treatment and decreased with high-phosphorous compound fertilizer. The iron treatment of 1.5 g l^{-1} was significantly superior to the rest of the treatments, recording a highest average of 2.09 mm and the comparison treatment recording the lowest rate, 1.30 mm.

The average stem diameter of Lalla Abbas plants was also significantly impacted by the compound fertilizer, with the best results coming from the 3 g l^{-1} treatment (2.16 mm vs. 1.24 mm), followed by the comparison treatment (1.24 mm).

The stem diameter of the Lalla Abbas plant was significantly larger (2.50 mm) in the interaction between iron and the compound fertilizer, specifically the interaction between iron 1.5 g l^{-1} and compound fertilizer 3 gl^{-1} and significantly smaller (1.75 mm) in the interaction of comparison treatment measured at 0.90 mm.

Table 1: Effect of iron treatment and compound fertilizer on average of plant height (cm).

Iron concentrations g l^{-1}	NPK concentrations g l^{-1}			Iron impact average
	0	1.5	3	
0	40.35	44.92	45.24	43.50
0.5	46.76	52.43	55.19	51.46
1.5	49.34	57.15	59.97	55.49
NPK impact average	45.48	51.50	53.47	
L.S.D.	Iron =1.56	NPK =1.56	Interaction = 2.32	

Table 2: Effect of iron treatment and compound fertilizer on Stem diameter (mm).

Iron concentrations g l^{-1}	NPK concentrations g l^{-1}			Iron impact average
	0	1.5	3	
0	0.90	1.35	1.64	1.30
0.5	1.30	2.11	2.34	1.92
1.5	1.51	2.25	2.50	2.09
NPK impact average	1.24	1.90	2.16	
L.S.D.	Iron =0.10	NPK =0.10	Interaction = 0.20	

Table 3: Effect of iron treatment and compound fertilizer on average of leaves number.

Iron concentrations g l^{-1}	NPK concentrations g l^{-1}			Iron impact average
	0	1.5	3	
0	73	85	97	85
0.5	81	125	140	115.33
1.5	93	137	145	125
NPK impact average	82.33	115.67	127.33	
L.S.D.	Iron =3.65	NPK =3.65	Interaction = 4.54	

3.3 The average of leaves number

Table 3 displays the study's findings regarding the effect of iron treatment and high-phosphorous compound fertilizer on the mean number of leaves produced by a Lalla Abbas plant. On average, 125 leaves were recorded in the iron 1.5 g l^{-1} treatment, which was significantly higher than the average of 85 leaves in the comparison treatment.

The compound fertilizer also significantly influenced the typical Lalla Abbas plant's leaf count, with the control treatment yielding the fewest leaves (82.33 on average) and the treatment with 3 g l^{-1} yielding the most (127.33).

The average number of leaves was highest for the interaction involving 1.5 g l^{-1} iron and 3 g l^{-1} compound fertilizer, significantly higher than the averages for the other interactions, and lowest for the comparison treatment. There were 73 of them by the end of it.

3.4 Average bulbs weight (g)

Table 4 showed the effect of iron treatment and high-phosphorous compound fertilizer on the average bulb weight of Lalla Abbas plant, as the iron treatment of 1.5 g l^{-1} was significantly superior and recorded a highest average of 113.21 g, but a control treatment recorded the lowest at 65.37 g.

The compound fertilizer also showed a significant effect on leaves number of Lalla Abbas plant; the treatment with 3 g l^{-1} was superior and showed a highest average at 116.56 g, while the lowest average was found in the normal control (at 61.36 g).

The average bulb weight of the Lalla Abbas plant was found to be 137.45 g when exposed to the interaction between iron 1.5 g l^{-1} and the compound fertilizer 3 g l^{-1}, significantly higher than the average weight of 45.79 g under the control treatment.

3.5 The number of Inflorescences (flowering inflorescence plant^{-1})

Table 5 showed the effect of iron treatment and high-phosphorous compound fertilizer on number of inflorescences on the plant Lalla Abbas. The lowest average of 12 flowering inflorescence plant^{-1} was

Table 4: Effect iron treatment, compound fertilizer on bulbs weight (g).

Iron concentrations g l^{-1}	NPK concentrations g l^{-1}			Iron impact average
	0	1.5	3	
0	45.79	66.84	83.47	65.37
0.5	58.54	110.34	128.77	99.22
1.5	79.74	122.43	137.45	113.21
NPK impact average	61.36	99.87	116.56	
L.S.D.	Iron = 5.68	NPK = 5.68	Interaction = 8.45	

Table 5: Effect of iron treatment and compound fertilizer on number of inflorescences (flowering inflorescence plant^{-1}).

Iron concentrations g l^{-1}	NPK concentrations g l^{-1}			Iron impact average
	0	1.5	3	
0	7	12	17	12
0.5	11	23	25	19.67
1.5	15	25	28	22.67
NPK impact average	11	20	23.33	
L.S.D.	Iron =2.32	NPK =2.32	Interaction = 3.12	

recorded in the comparison treatment. The compound fertilizer had a significant effect as well, with the treatment with 3 g/l outperforming the others and recording the highest mean significant amounted to 23.33 flowering inflorescence plant^{-1}, but a control treatment gave a lowest average of 11 flowering inflorescence plant^{-1}.

As for the interaction between iron and the compound fertilizer, the interaction between iron 1.5 g l^{-1} and the compound fertilizer 3 g l^{-1} gave a highest average of the number of flowering inflorescences of Lalla Abbas plant, reached a maximum of 28 flowering inflorescences plant^{-1}, significantly higher than any of the other interactions, while the comparison treatment averaged only 7.

3.6 Florets number in the inflorescence

Table 6 showed effect of iron treatment and high-phosphorous compound fertilizer on the rate of the number of flowers in inflorescence plant^{-1} of the plant of Lalla Abbas, as the treatment of iron 1.5 g l^{-1} was significantly superior to the rest of the treatments and recorded the highest average of 54.67, while the comparison treatment recorded the lowest average of 34.00. The compound fertilizer also made a noticeable difference, with the 3 g l^{-1} treatment showing the greatest improvement (with an average of 53.67) and the comparison treatment showing the least (with an average of 25.33). An inflorescence plant^{-1} flower averages 32.67 points.

The highest average was found for the interaction between iron and compound fertilizer, with iron 1.5 g l^{-1} and compound fertilizer 3 g l^{-1} producing 69 flowers of inflorescence plant^{-1}. A total of 25 inflorescence plant^{-1} flowers were averaged as interference for the comparison treatment.

3.7 Carotenoids leaves content (mg 100 g fresh^{-1})

Table 7 demonstrated effect of iron treatment and high-phosphorous compound fertilizer on the carotenoids content of the Lalla Abbas plant's leaves, with the iron treatment of 1.5 g/l being significantly superior to the other treatments and recording the highest rate of 1.562 mg/100 g fresh^{-1}, while a comparison treatment recorded a lowest average of 0.877 mg/100 g fresh^{-1}.

The compound fertilizer also had a significant content of carotenoids in the leaves of the Lalla Abbas plant, with the treatment with 3 g/l outperforming the other treatments and recording the highest significant average of 1.593 mg/100 fresh g^{-1}, while a control treatment recorded a lowest rate of 0.865 mg/100 fresh g^{-1}.

The highest rate of carotenoids in the leaves of the Lalla Abbas plant was recorded in the interaction between iron (1.5 g l^{-1}) and the compound fertilizer (3 g l^{-1}). This interaction was significantly different from the others. In contrast, the lowest rate was found in the interaction for the control group, at 0.778 mg100 g of fresh^{-1}.

3.8 Total chlorophyll leaves content (mg100 g^{-1})

Table 8 displays the total chlorophyll content of Lalla

Table 6: Effect iron treatment, compound fertilizer on florets number in the inflorescence.

Iron concentrations g l^{-1}	NPK concentrations g l^{-1}			Iron impact average
	0	1.5	3	
0	25	36	41	34.00
0.5	33	46	51	43.33
1.5	40	55	69	54.67
NPK impact average	32.67	45.67	53.67	
L.S.D.	Iron =3.45	NPK =3.45	Interaction = 5.34	

Table 7: Effect of iron treatment and compound fertilizer on Carotenoids leaves content (mg 100 g fresh^{-1}).

Iron concentrations g l^{-1}	NPK concentrations g l^{-1}			Iron impact average
	0	1.5	3	
0	0.778	0.896	0.956	0.877
0.5	0.893	1.345	1.835	1.358
1.5	0.923	1.777	1.987	1.562
NPK impact average	0.865	1.339	1.593	
L.S.D.	Iron = 0.11	NPK = 0.11	Interaction = 0.17	

Abbas leaves after being treated with iron and given high-phosphorous compound fertilizer. With an average of 14.09 mg100 g^{-1}, the iron treatment at 1.5 g l^{-1} was clearly superior to the other treatments, while the comparison treatment only managed an average of 10.50 mg100 g^{-1}.

Similarly, the total chlorophyll content of the leaves of the Lalla Abbas plant was significantly affected by the compound fertilizer, with the treatment of 3 g l^{-1} being superior to the rest of the treatments and recording the highest significant average of 14.05 mg100 g^{-1} and the comparison treatment recording the lowest average of 9.90 mg100 g^{-1}.

The mean total chlorophyll content of the Lalla Abbas plant's leaves was 15.58 mg100 g^{-1}, when the iron concentration was 1.5 g l^{-1} and the compound fertilizer concentration was 3 g l^{-1}. This interaction significantly differed from the others. The lowest average was found in the control group, at 0.128 mg100 g^{-1}.

3.9 Leaf carbohydrate content (mg.100g^{-1})

Carbohydrate content in Lalla Abbas leaves was affected by iron treatment and high-phosphorous compound fertilizer, as shown in Table 9. The iron 1.5 g l^{-1} treatment was the most effective of the bunch, with an average of 110.70 mg100 g^{-1} compared to the comparison treatment's 89.12 mg100 g^{-1}.

Carbohydrate content of Abbas plant leaves was also significantly affected by the compound fertilizer, with the 3 g l^{-1} treatment being superior to the rest of the treatments and recording the highest significant average of 111.36 mg100 g^{-1} and the comparison treatment recording the lowest average of 81.59 mg 100 g^{-1}.

The highest leaf carbohydrate content of the Lalla Abbas plant was recorded for the interaction between iron 1.5 g l^{-1} and the compound fertilizer 3 g l^{-1}, with a significant difference from the other interactions; the interference for the comparison treatment recorded the lowest, at 71.91 mg100 g^{-1}.

Through the research, it was shown that the interaction between the high-phosphorus compound fertilizer and the iron element gave better results than each agent alone, which caused an improvement in the characteristics of vegetative, flowering growth and the chemical content of the Abbas plant. Also, spraying with iron may help the absorption of phosphorus in plant tissues or through its control of the biological and chemical reactions of the processes of respiration, cell division, and carbon metabolism. It also reflects positively on plant traits such as early growth, dry weight increase, plant leafy area, flowering and the formation of seeds, as well as works on the development of roots, such as increasing the length and density of roots and the formation of lateral roots and root hairs in some plants and works to strengthen the stems [Goulding *et al*. (2008)].

The iron element also has important functions in the nutritional metabolism of plants, such as activating catalase enzymes associated with the enzyme dismutase

Table 8: Effect iron treatment, compound fertilizer on total chlorophyll leaves content (mg100 g^{-1}).

Iron concentrations g l^{-1}	NPK concentrations g l^{-1}			Iron impact average
	0	1.5	3	
0	.128	11.27	12.11	10.50
0.5	9.42	13.46	14.45	12.44
1.5	12.16	14.53	15.58	14.09
NPK impact average	9.90	13.09	14.05	
L.S.D.	Iron = 0.92	NPK =0.92	Interaction = 1.23	

Table 9: Effect iron treatment, compound fertilizer on leaf carbohydrate content (mg.100g^{-1}).

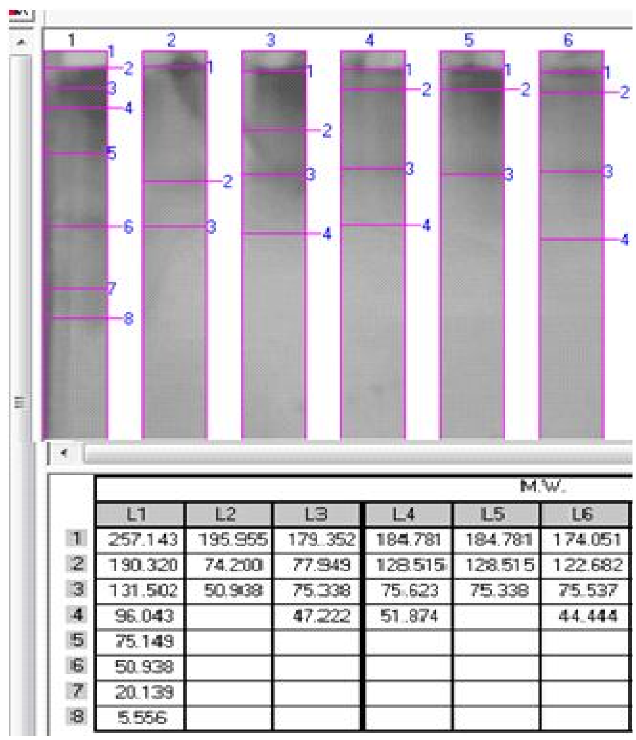
Iron concentrations g l^{-1}	NPK concentrations g l^{-1}			Iron impact average
	0	1.5	3	
0	71.91	95.34	100.12	89.12
0.5	84.76	112.44	111.21	102.80
1.5	88.11	121.22	122.76	110.70
NPK impact average	81.59	109.67	111.36	
L.S.D.	Iron =1.15	NPK =1.15	Interaction = 3.24	

superoxide, as well as the formation of chlorophyll through its important role in the formation of carbohydrates, as it is considered part of the ferredoxin protein. It is also an important element because it works to activate the enzymes that contribute to the oxidation and reduction processes, is involved in the synthesis of cytochrome and ferodoxin [Briat *et al.* (2014)] and increases plant resistance.

3.10 Leaf prototype

The protein pattern of the investigated Abbas plant leaves (Fig. 1) reveals that the number, position and characteristics of protein bands on the polyacrylamide gel vary between these plants. The total number of protein bands varied from 3 to 4 and was proportional to the dose and type of treatment. There were three protein bands in each of the control treatment and the comparison overlap treatment, while four protein bands appeared in each of the iron treatment with a concentration of 1.5 g l^{-1} and the NPK treatment with a concentration of 3 g l^{-1}, as well as in the interaction treatment between the iron treatment with a concentration 1.5 g l^{-1} with treatment of NPK at a concentration of 3 g l^{-1}. These results indicate that these plants belong to the same origin, as they shared the presence of the first protein package with close molecular weights.

The treatments significantly affected the gene expression process of Lalla Abbas plants and caused the emergence of a new protein bundle, indicating that the study treatments stimulated the cells to manufacture



	L1	L2	L3	L4	L5	L6
1	257.143	195.955	179.352	184.781	184.781	174.051
2	190.320	74.200	77.949	128.515	128.515	122.682
3	131.502	50.938	75.338	75.623	75.338	75.537
4	96.043		47.222	51.874		44.444
5	75.149					
6	50.938					
7	20.139					
8	5.556					

Fig. 1: Number, locations molecular weight distributions and band intensities of protein Lalla Abbas plant treated with iron and high-phosphorous compound fertilizer (a part of the Photocapt program). 1-Marker, 2-Control, 3- Fe, 1.5 g l^{-1}, 4-NPK, 3g l^{-1}, 5- control of intraction, 6- intraction, Fe 1.5 g l^{-1} +NPK 3 g l^{-1}

new proteins that support indicators of growth and development in the treated plants. The treatments caused activation of gene expression and the manufacture of new proteins that may have a role in improving plant growth and this was confirmed by the current study in the physico-chemical characteristics of plants. Among all treatments, there was a clear and substantial convergence in the molecular weights of the first protein bundle, which ranged from 174.051 to 195.955 kDa. When treating iron at a concentration of 1.5 g l^{-1}, the molecular weight of the second package peaked at 128.515 kilotons.

These results indicate that the treatment of plants with iron and high-phosphorous compound fertilizer may lead to the synthesis of natural proteins, as well as adjustments to gene expression (*i.e.*, translation and transcription) that result in the creation of novel proteins in line with the plant's requirements and the nature of the treatment, thereby promoting enhanced plant growth [David and Nelson (2000)].

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