The effect of nutrition with chelated iron and boron on some vegetative growth indicators and photosynthetic pigments of pea leaves (Pisum sativum)

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Abstract
A field experiment was conducted for the agricultural season 2022-2023 at the Agricultural Research Station affiliated to the College of Agriculture, University of Basrah, at the Karmat Ali site. To study the effect of spraying different concentrations of iron and boron (0, 100, 200) mg L-1 for each of them individually or mixing the two elements in addition to the comparison treatment and according to the design of complete randomized sectors and with nine treatments and three replicates so that the number of experimental units reached 27 units in the indicators of vegetative growth and leaf content of total chlorophyll and carotene pigments and the percentage of total dissolved solids in seeds. The results showed that foliar spraying with both iron and boron together at a concentration of 200 mg L-1 for each caused a significant increase in plant height, fresh and dry weights of the plant, and leaf area of the plant while spraying with iron at a concentration of 100 mg L-1 caused a significant increase in the number of leaves. Spraying with boron alone at a concentration of 100 mg L-1 led to a significant increase in the carotene content of the leaves while spraying with boron at a concentration of 200 mg L-1 led to a significant increase in the percentage of total soluble solids in the seeds.

Keywords; Pea plant; iron, boron; vegetative growth; photosynthetic pigments; total soluble solids in seeds.

Introduction

Green peas Pisum sativum L. belongs to the legume family Fabaceae. They are grown for their fresh green seeds, tender green pods, or dry seeds (Matloub et al., 1989) which have good nutritional value due to their high content of protein, carbohydrates, phosphorus, magnesium, iron, calcium, riboflavin, niacin and thymine (Hassan, 2002). From an agricultural perspective, peas play an important role in the agricultural cycle as they are one of the crops that contribute to fixing atmospheric nitrogen and improving soil fertility (Davies et al., 1985). Fertilization is one of the most important agricultural service operations and one of the important means of production due to its significant effect in regulating the physiological processes of the plant, especially nutrition with microelements, including iron and boron, which are necessary for plant growth and completion of its life cycle, although the plant needs them in very small quantities (Haque et al., 2011). It can be given to the plant by spraying it on the green group, either in a single form or mixed (Abu Dahi and Al-Younes, 1988).

This method is used to avoid nutritional deficiencies and its effectiveness in treating problems of soil element availability. Iron plays a fundamental and essential role in many

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enzymes involved in the respiration process, including Catalase, Peroxidase, Cytochorme oxidase. Iron's participation in these compounds is of particular importance in oxidation and reduction reactions and is one of the important roles in the cell's metabolic processes (Al-Maraqi, 2005). It also has a fundamental role in the representation of nucleic acids and chloroplasts, as it helps in the manufacture of chlorophyll, especially in higher plants such as peas, and it enters into the construction of cytochromes, which are of great importance in the processes of photosynthesis and respiration (Tiaz and Zeiger, 2002). Nenova (2006) noted that adding iron to Hochland solution in hydroponic cultivation of pea plants at different concentrations (40, 10, 2, 1.0) mg L-1 caused a concentration of 2 mg L-1 after 41 days of cultivation, a significant increase in plant length and stem dry weight, while a concentration of 40 mg L-1 led to a significant increase in leaf content of chlorophyll a, b. Dekdage (2015) noted that when spraying pea plants of the Little Marvel variety with iron at a concentration of 500 mg L-1, there was a significant increase in plant length, number of leaves, fresh and dry weight of the plant, and leaf content of chlorophyll a, b compared to the control treatment for both seasons of the experiment. El Sherbini et al. (2015) indicated that spraying pea plants with different concentrations of nano-iron (400, 300, 200, 100.0) mgL-1 in addition to Spraying with chelated iron at a concentration of 500 mg L-1 caused a significant increase in leaf area, dry weight of the plant, and leaf content of chlorophyll pigment Spad for both seasons of the experiment. Nasser et al (2022) showed that spraying pea plants with iron at a concentration of 250 mg L-1 caused a significant increase in stem length, fresh and dry weight of the vegetative group, leaf area, chlorophyll pigment a, b, carotene, and the percentage of soluble sugars compared to unsprayed plants.

Boron is an essential element for plants, as it plays a major and positive role in cell development, increasing cell division, and building cell walls. In addition, boron deficiency reduces the formation of the growth hormone cytokinin, which is responsible for delaying plant aging (Mengel and Kirkby, 1987). Good boron nutrition also maintains water balance in plant cells, which may be due to its importance in increasing the plant's efficiency in absorbing potassium (Abu Dahi and Al-Younes 1988) and its effect on the photosynthesis process, stimulating chlorophyll, enzymatic activity, and the movement of auxins inside the plant. It contributes to regulating the osmotic potential of the stomata (Havlin et al. 2005). El-Waraky et al. (2013) noted that when spraying Master B pea plants with different concentrations of boron (15, 10, 5, 0) mg L-1, spraying with a concentration of 10 mg L-1 caused a significant increase in plant length, number of leaves, leaf area, fresh weight of the plant, and leaf content of Chlorophyll and both growth seasons compared to the comparison treatment. Sutuliene et.al.(2021)obtained that when spraying pea plants of the Respect variety with different concentrations of nano-boron (100, 50, 25, 12.5, 0) mg L-1, the concentration of 12.5 mg L-1 significantly increased the stem length and fresh and dry weight of the plant. Rashid and Mosleh(2023) indicated that spraying pea plants of the Garden Pea variety with different concentrations of boron (150, 100, 50, 0) mg L-1 significantly increased the concentration of 150 mg L-1 in increasing the percentage of total dissolved solids in the seeds. Khiangte et.al. (2023) indicated that adding boron with seed inoculation with Rhizobia bacteria at levels (2, 1.5, 1, 0.5) kg B ha-1 in addition to the comparison treatment without adding two pea varieties Azda, Arkel Azda cultivar plants were significantly superior when 1.5 kg B ha-1 was added with rhizobia in increasing plant height, fresh and dry weight of the plant, number of leaves and total chlorophyll content of the leaves.

Al-Akeedi (2002) showed that spraying peas with a mixture of iron and boron led to an increase in vegetative growth compared to spraying each element separately and the comparison treatment, as indicated by Masoud (2013) in his study on the effect of loading between the Brunswick variety of cabbage and the B Master variety of peas and foliar nutrition with boron at concentrations of (80, 50.0) mg L-1 and iron at concentrations of (200, 100.0) mg L-1. Spraying with boron at a concentration of 50 mg L-1 and iron at a concentration of 200 mg L-1 led to a significant increase in the height, number of leaves, leaf area and fresh weight of pea plants for both seasons of the experiment. Due to the scarcity of studies on the effect of foliar spraying of iron and boron elements individually or mixed at different concentrations on the growth and chemical components of the leaves of pea plants grown in southern Iraq, this study was conducted.

Materials and Methods

The experiment was carried out in the fields of the Agricultural Research Station belonging to the College of Agriculture, University of Basrah, in the Karmat Ali area during the agricultural season 2022-2023 in a sandy mixture soil (Table 1). The land was plowed perpendicularly, smoothed, leveled, and fertilized with animal manure, and decomposed cow waste, at a rate of 40 tons per hectare-1, and divided into three holes with a length of 27 m and a distance of 80 cm between them. Syrian pea seeds were planted on 11/2/2022 using 3 seeds per hole and with a distance of 25 cm between one hole and another. After germination was complete, they were thinned to one plant. Each hole was considered a single sector, and 9 foliar fertilization treatments were distributed randomly. The length of the experimental unit was 3 m, containing 12 plants, and the following fertilizer treatments were included:

1- Comparison treatment (without spraying)

2- Spraying with chelated iron at a concentration of 100 mg L-1

3- Spraying with chelated iron at a concentration of 200 mg L-1

4- Spraying with boron at a concentration of 100 mg L-1

5- Spraying with boron at a concentration of 200 mg L-1

6- Spraying with chelated iron at a concentration of 100 mg L-1 +Spraying with boron at a concentration of 100 mg L-1

7- Spraying with chelated iron at a concentration of 100 mg L-1 + Spraying with boron at a concentration of 200 mg L-1

8- Spraying with chelated iron at a concentration of 200 mg L-1 + Spraying with boron at a concentration of 100 mg L-1

9- Spraying with chelated iron at a concentration of 200 mg L-1 + Spraying with boron at a concentration of 200 mg L-1.

Spraying at a rate of three sprays, the first one after one month of complete germination and with a two-week interval between each spray, with the addition of Tween 20 as a spreading material. The following vegetative growth indicators were studied: plant length (cm), number of leaves, fresh and dry weight of the

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vegetative mass (g), leaf area (dm2) according to the method described by (Waston and Waston, 1953). The total chlorophyll pigment in the green leaves was estimated according to the method described by (Goodwin, 1976) and the carotene pigment according to what was mentioned by (Zaehringer et. al, 1974). The results were analyzed statistically according to the design followed, complete randomized sectors and three replicates, and according to the statistical program Genstat. The arithmetic means of the treatments were compared according to the least significant difference test (LSD) at a significance level of 0.05 (Al-Rawi and Khalaf Allah, 1980).

Table (1): Some chemical and physical characteristics of the study soil

Attribute		Value	Unit
pH		7.7	
ECE		5.22	ds m^{-1}
Available Phosphorus		38.8	mg kg^{-1}
Total Nitrogen		0.23	g kg^{-1}
Ready Potassium		101.20	mg kg^{-1}
solube positive ions	Calcium	16.5	millimoles l^{-1}
	Magnesium	11	
	Sodium	21.3	
	Bicarbonates	13.6	
	Sulfates	18.5	
	Chlorides	28.0	
Soil separators	Sand	593	G kg-1
	Silt	271.5	
	Clay	135.5	
Soil texture		sandy loam	

Results and discussion

It is clear from Table (2) that spraying pea plants with both iron and boron together at a concentration of 200 mg L-1 for each of them caused a significant increase in plant height, fresh and dry weights of the plant, and leaf area compared to the rest of the treatments, whether the control treatment or the two elements individually or in combination and at other different concentrations, as they reached (72.0 cm, 31.60 g, 7.58 g, 46.64 dm2), respectively, while spraying with iron alone at a concentration of 100 mg L-1 caused a significant increase in the total number of leaves compared to the rest of the other treatments, as it reached 29 leaves. The significant increase may be attributed to the role of both elements in many vital processes in the plant, as iron is a very important element, especially for plants of the legume family, as it enters into the composition of the nitrogenase enzyme responsible for fixing atmospheric nitrogen and its contribution to the activity of leghemoglobin in the root nodules of these crops (Brill, 1980), in addition to Its role in increasing the activity of respiratory enzymes and plant cells and thus increasing energy production (Abdul, 1988) which is used in absorbing nutrients that contribute to increasing the process of

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photosynthesis and increasing its products as well as the chemical properties of chelated iron and its high ability to chelate iron and its stability and ability to supply iron to the plant during the different stages of growth (Goos et al, 2004.(

Table (2). Effect of foliar nutrition with chelated iron and boron, individually or in combination, on some vegetative growth indicators of pea plants.

Treatments mgL^{-1}	Plant Height (cm)	Leaves number	Fresh weight of vegetative group (g)	Dry weight of vegetative group (g)	Leaves area (dm^2)
Control	62.33	22.00	23.89	4.767	38.61
Fe 100	56.00	29.00	25.33	5.227	30.93
Fe 200	53.00	19.00	19.63	3.520	20.91
B 100	35.00	26.00	22.33	3.000	35.00
B 200	39.33	16.00	14.00	5.650	21.74
Fe 100 + B 100	54.33	21.33	21.30	4.817	35.29
Fe 100 + B 200	42.67	17.00	10.67	2.480	19.84
Fe 200 + B 100	42.00	19.00	14.30	3.200	30.73
Fe 200 + B 200	72.00	27.00	31.60	7.580	46.64
LSD 0.05	**4.79**	1.74	6.02	0.473	3.56

Boron also contributes to the process of cell division and expansion in meristematic tissues and growing tips and has an important role in the construction and movement of plant hormones, especially IAA (Opik and Rolfe, 2005) and increasing the transfer of materials manufactured in the process of photosynthesis to the places where they are needed in the plant (lssa, 1990), which all contributed to increasing the indicators of vegetative growth of the plant. These results are consistent with what was obtained by (Al-Akeedi, 2002, Masoud, 2013) when spraying both elements together and (2015) Dakiega when spraying only the iron element.

Table (3) shows that spraying plants with boron only at a concentration of 100 mg L-1 led to a significant increase in the content of carotene pigment in the leaves compared to the comparison treatment, as it reached 0.1843 mg per 100 g-1 fresh weight, while spraying with a concentration of 200 mg L-1 for boron only caused A significant increase in the percentage of total soluble solids in the seeds compared to the rest of the treatments, reaching 5.633%.

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Table (3). Effect of foliar nutrition with chelated iron and boron, individually or in combination, on the leaf content of photosynthetic pigments and the percentage of total soluble solids in seeds.

Treatments	Total chlorophyll in leaves mg $100g^{-1}$ fresh weight	Carotene in leaves mg 100 g^{-1} fresh weight	Total soluble solids percentage in seeds
Control	9.230	0.1640	4.000
Fe 100	9.520	0.1717	3.967
Fe 200	9.500	0.1473	3.600
B 100	9.303	0.1843	5.100
B 200	9.340	0.1717	5.633
Fe 100 + B 100	9.373	0.1700	3.667
Fe 100 + B 200	9.500	0.1540	4.333
Fe 200 + B 100	8.240	0.1440	5.467
Fe 200 + B 200	8.850	0.1660	4.233
LSD 0.05	N.S	0.0106	0.530

While the spray treatments for both elements did not significantly affect the total chlorophyll content of the leaves. The significant superiority of spraying with boron only in carotene pigment in the leaves and the percentage of total dissolved solids in the seeds may be attributed to the role of boron in improving many vital processes during the different growth stages, including cell division and elongation, its entry into the composition of cell membranes, nitrogen metabolism, photosynthesis, completion of physiological growth of the seed embryo, and maintaining water balance in plant cells (Abu Dahi and Al-Younes, 1988), which all contributed to raising the carotene content of the leaves and the percentage of total dissolved solids in the seeds. This result is consistent with what was obtained by (Rashid and Mosleh, 2023.(

Conclusion

Can conclude from this study that spraying with chelated iron at a concentration of 200 mg L-1 and boron at a concentration of 200 mg L-1 led to improving the vegetative growth characteristics, and spraying with boron at a concentration of 100 mg L-1 led to increasing the carotene pigment in the leaves, and at a concentration of 200 mg L-1 led to increasing the percentage of total soluble solids in the seeds.

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