The effect of spraying with iron and boron on some chemical contents of the leaves of two hybrid broccoli plants

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Abstract

The field experiment was conducted during the 2024-2025 agricultural season at the Agricultural Research Station of the College of Agriculture at the University of Basra, with the aim of studying the effect of four concentrations of a combination of boron and iron (0, 150 iron, 100 boron, 150 iron + 100 boron) mg L^{-1} on two hybrids of broccoli plants (umbrella, jasmine,). Completely randomized block factorial experiment with three replications, the most important results are summarized as follows: The results obtained showed Spraying with a concentration of (150 iron + 100 boron) mg L^{-1} was superior to the rest of the concentrations in the chemical contents of the studied leaves (carbohydrates, chlorophyll, and the nutrients nitrogen, phosphorus, and potassiuim), as it gave 6.92%, 3.15 mg 100 gm^{-1} - fresh weight, 5.20%, 0.531%, and 2.175%, respectively . Additionally, the outcomes showed The Umbrella hybrid also excelled in the studied chemical contents (carbohydrates, chlorophyll, percentage of nitrogen, phosphorus, and potassium), as it gave the highest percentage, reaching 6.55%, 2.83 mg 100 gm^{-1} fresh weight, 4.88%, 0.468%, and 2.067%, respectively. The binary interactions of the experimental factors also had a significant effect on the studied traits, as the interaction between spraying (150 iron + 100 boron) mg L^{-1} on the umbrella hybrid was superior compared to the rest of the interactions.

Keywords: broccoli, boron, iron, foliar nutrition.

Introduction

Broccoli, whose is *Brassica oleracea* var. italica، which belongs to the cruciferous family Brassicacae and is considered an important winter vegetable crop in many countries of the world، It is a herbaceous plant that resembles cauliflower in morphological terms (Pankaj and Saravanan, 2018).

It is characterized as a rich source of antioxidants and vitamins such as vitamins B1, C, and also rich in vitamins A, B2. Every 10g of broccoli inflorescences contains 89.1g of water, 32 calories, 3.6 protein, 0.3g of fat, and 5.9g of carbohydrates. It also contains nutrients such as iron, calcium, zinc, sulfur, and potassium (Vasanthi and Das, 2009). It also contains beta-carotene, and its leaves are a source of polyphenols, fats, and fiber (Chowdhury and Sikder, 2017). Its cultivation has spread in Iraq recently, and it is grown in order to obtain its pink inflorescences, which are eaten while they are in the flower bud stage with their tender pods. It is considered one of the richest crops in terms of nutrition, and has many therapeutic uses. Eating broccoli helps lower the level of cholesterol in the blood and regulate sugar. It also reduces the incidence of cancer by up to 45%. It also helps build bones and protect against heart disease. It is believed that the original homeland of the broccoli plant is the areas surrounding the Mediterranean Sea, which is grown in many countries of the world such as Italy, America, China, Spain, the Middle East countries, as well as in Asian countries (Kirsh *et al*., 2007) . The cultivated area in the world reached approximately 1,357,185 hectares, with a productivity rate of 25,531,274 tons ha-1, while the cultivated area in Iraq reached approximately 1133 hectares with a productivity rate of 12361 tons ha^{-1} (F.A.O, 2020).

Foliar feeding is considered one of the most efficient fertilization methods, as the absorption of nutrients is faster through the leaves if those elements are not ready in the soil. Adding micronutrients plays a major role in improving growth and production through their participation in various physiological process ses within the plant. Among these elements is iron, which is one of the essential micronutrients for the plant, because it affects many important physiological processes in the plant. Understanding iron balance in plants is pivotal; Iron contributes to vital processes in plants by being an activator of enzymes related to the process of respiration and electron transfer (Mahawar *et al.,*2022).

Boron also affects plant growth, cell division and elongation, and has a major role in transporting food manufactured in leaves to storage areas (Al-Dulaimi, 2020).

Boron is one of the elements that is easy to lose compared to other microelements, so foliar fertilization with boron is the ideal way to treat boron deficiency in plants. Scientific studies have proven the effectiveness of foliar fertilization of boron in filling the deficiency of this element. The boron element has important functions, as it controls the percentage of water inside the plant, as well as its relationship to the movement of sugars to their storage places, because it reduces polarization and reduces the effort required for their transfer (Sharafi, 2021).

In light of what was mentioned above, the study aims to: . Knowing the role of iron and boron and their interaction in producing a broccoli crop with nutritional value and high chemical content.and Study of two hybrids of broccoli and their suitability for cultivation under the conditions of Basra Governorate.

Materials and Methods

Experiment field

A field experiment was conducted at the research station belonging to the College of Agriculture / University of Basra for the agricultural season 2024-2025 to demonstrate the effect of foliar spraying with chelated iron Fe-EDDHA (Chelate-Iron) and boron in the form of boric acid (HBO3) containing 17% boron and the interaction between them in some chemical components of two hybrids of broccoli plants. The experiment was carried out according to a completely randomized block design (RCBD). With three replications, the average results were analyzed statistically using the statistical program tdec-2008-31 GenStat, and the Rate of Least Significant Differences Test (.L.S.D.) was used to compare the averages at a probability level of 0.05 (Al-Rawi, and Khalaf Allah ,1980).

The experiment included 8 factorial parameters representing the possible combinations between spraying four concentrations of iron and boron (0, 150 iron, 100 boron, 150 iron + 100 boron) mg L^{-1} on two hybrids of broccoli (Umbrella, Jasmine) with three sprays. The first spray was a month after planting the seedlings in the field soil, and the period was between one spraying and the next. 15 days, according to a completely randomized block design with three replications, so the number of experimental units is 24 experimental units.

The seedlings were planted at one month old after the field soil was plowed twice perpendicularly, smoothed and leveled. Then it was divided into three sectors with a depth of 30 cm. The soil was smoothed using disc harrows and leveled. A sample of the soil was taken and analyzed before planting for the purpose of showing the physical and chemical characteristics of the research soil, Table (1).

Table 1. Some physical and chemical characteristics of the soil in which plants are grown

Value	Unit of measurement	.Adjective
7.6	------	Ph
6.55	Ds .$m^{1=}$	EC
Sandy Mxture	Silty loam	Tissue
65.24	Mg L^{1-}	.Sandy
16.41	Mg L^{1-}	Green
18.45	Mg L^{1-}	Clay
2.90	Mg L^{1-}	N
3.45	Mg L^{1-}	P
4.81	Mg L^{1-}	K

Studied qualitative and chemical characteristics

1- Percentage of carbohydrates in leaves (%):

The carbohydrate character of the leaves was estimated according to the method mentioned by (Krishnaveni, and Sadasivam,1984).

2- Total chlorophyll in leaves (mg 100g fresh weight)

Chlorophyll pigment in leaves was estimated according to the method of (Goodwin, 1976).

3- The percentage of nitrogen in the leaves

The samples were digested, and total nitrogen in the digested samples was estimated using a Microkjeldhal steam distiller based on the method of (Jackson,1958).

4- The percentage of phosphorus in the leaves

Ammonium vanadomolybdate was determined for previously digested samples according to the method of (Pageand Keeney, 1982).

5- The percentage of potassium in the leaves

Potassium in digested samples was determined using a Flame Photometer according to the method of (Pageand Keeney, 1982).

Results

1- Leaves content of total soluble carbohydrates (%)

It is noted from Table (2) that the spraying treatment with iron and boron showed a significant effect between the treatments, as the treatment (150 iron + 100 boron) mg L^{-1} recorded the highest average, amounting to 6.92%, while the comparison treatment recorded the lowest average, amounting to 5.23%.

It is also noted that the hybrid has a significant effect, as the Umbralla hybrid outperformed, giving the highest value of 6.55%, over the Jassamine hybrid, which gave the lowest value of 5.89%.

As for the interaction between the study factors, significant differences appeared between them. The treatment with spraying (150 iron + 100 boron) mg L^{-1} on the hybrid Umbralla recorded the highest value, amounting to 7.10%, while the treatment without spraying on the hybrid Jassamine recorded the lowest value, amounting to 4.78%.

Table 2. The effect of spraying with iron and boron on two hybrids of broccoli and the interaction between them in the carbohydrate content of the leaves (%)

Hybrid	Treatment				Hybrid average
	0	150mg L^{-1} iron	100 mg L^{-1} boron	(150iron + 100 boron) mg L^{-1}	
Umbrella	5.68	6.55	6.87	7.10	6.55
Jassamine	4.78	5.98	6.08	6.74	5.89

average with iron and boron	5.23	6.26	6.48	6.92	
LSD 0.05					
0.297		0.714		0.883	

2- Leaves' total chlorophyll content (mg 100g^{-1} fresh weight)

It is noted from Table (3) that foliar spraying with iron and boron has a significant effect on the total chlorophyll content of the leaves, as the spraying treatment with (150 iron + 100 boron) mg L^{-1} recorded the highest percentage, amounting to 3.15 (mg 100 gm^{-1}), while the control treatment recorded the lowest percentage, amounting to 1.72 (mg 100 gm^{-1}). It is also noted that the Umbrella hybrid was significantly superior to the Jassamine hybrid, as it gave 2.83 (mg 100 g^{-1}) and 2.37 (mg 100 g^{-1}), respectively.

As for the bilateral interaction between the study factors, a significant effect appeared on the chlorophyll content of the leaves, as the interaction between the treatment (150 iron + 100 boron) mg L^{-1} and the Umbrella hybrid recorded the highest percentage, amounting to 3.34 (mg 100 gm^{-1}), while the interaction between the control treatment and the hybrid Jassamine recorded the lowest percentage, amounting to 1.46 (mg 100 gm^{-1}).

Table 3. The effect of spraying with iron and boron on two hybrids of broccoli and the interaction between them in the chlorophyll content of the leaves (mg 100 g^{1} - fresh weight)

Hybrid	Treatment				Hybrid average
	0	150 mg L^{-1} iron	100 mg L^{-1} boron	(150iron + 100 boron) mg L^{-1}	
Umbrella	1.98	2.79	3.21	3.34	2.83
Jassamine	1.46	2.61	2.43	2.97	2.37
average with iron and boron	1.72	2.70	2.82	3.15	
LSD 0.05					
0.105		0.307			0.391

3 Nitrogen content of leaves %

It is noted from Table (4) the significant effect of treatment with iron and boron on the nitrogen content of the leaves, as the treatment (150 iron + 100 boron) mg L^{-1} recorded the highest percentage, amounting to 5.20%, while the lowest percentage was recorded, amounting to 3.57%, when sprayed with the comparison treatment.

Significant differences also appeared between the hybrids, as the Umbrella hybrid excelled by giving the highest nitrogen content, amounting to 4.88%, while the Jassamine hybrid gave the lowest value, amounting to 4.28%.

As for the interaction between foliar spraying with iron and boron and the two hybrids, there were significant differences between the treatments, as the spraying treatment with (150 iron + 100 boron) mg L^{-1} on the Umbrella hybrid recorded the highest rate of 5.37%, while the comparison treatment on the Jassamine hybrid recorded the lowest rate of 3.04%.

Table 4. Effect of spraying with iron and boron on two hybrids of broccoli and the interaction between them in the nitrogen content of the leaves (%)

Hybrid	Treatment				Hybrid average
	0	150 mg L^{-1} iron	100 mg L^{-1} boron	(150iron + 100 boron) mg L^{-1}	
Umbrella	4.09	4.84	5.23	5.37	4.88
Jassamine	3.04	4.44	4.60	5.03	4.28
average with iron and boron	3.57	4.64	4.91	5.20	
LSD 05 .0					
0.313			0.385		

4- Phosphorus content of leaves (%)

It is noted from Table (5) that the treatment of spraying plants with iron and boron had a significant effect on the phosphorus content of the leaves, as the treatment (150 iron + 100 boron) mg L^{-1} recorded the highest percentage, amounting to 0.531%, while the lowest percentage, amounting to 0.324%, appeared in the comparison spray treatment.

It is also noted that there are significant differences between the hybrids, as the Umbrella hybrid excelled and recorded the highest phosphorus content, amounting to 0.468%, while the Jassamine hybrid gave the lowest value, amounting to 0.401%.

As for the interaction between foliar spraying with iron, boron, and hybrids, significant differences appeared, as the spraying treatment with (150 iron + 100 boron) mg L^{-1} on the Umbrella hybrid recorded the highest percentage, amounting to 0.567%, while the comparison treatment and the hybrid Jassamine recorded the lowest percentage, amounting to 0.264%.

Table 5. Effect of spraying with iron and boron on two hybrids of broccoli and the interaction between them in the phosphorus content of the leaves (%)

Hybrid	Treatment				Hybrid average
	0	150mg L^{-1} iron	100 mg L^{-1} boron	(150iron + 100 boron) mg L^{-1}	
Umbrella	0.384	0.468	0.524	0.567	0.468
Jassamine	0.264	0.417	0.428	0.495	0.401
average with iron and boron	0.324	0.442	0.476	0.531	
LSD	0.05				
	0.0142	0.0368		0.0472	

5- Potassium content of leaves: %

It is noted from the results shown in Table (6) the significant effect of spraying with iron and boron on.the potassium content of the leaves, as the treatment (150 iron + 100 boron) mg L^{-1} recorded the highest percentage, amounting to 2.175%, while the lowest percentage was recorded, amounting to 1.776%, in the comparison treatment.

It is also noted that there are significant differences between the hybrids, as the Umbrella hybrid was superior by giving the highest value of the potassium content of the leaves, amounting to 2.067%, while the Jassamine hybrid gave the lowest value, amounting to 1.906%.

As for the interaction between hybrids and foliar spraying, there were significant differences between the treatments, as the treatment (150 iron + 100 boron) mg L^{-1} on the Umbrella hybrid recorded the highest rate of 2.315%, while the interaction between the comparison treatment on the Jassamine hybrid recorded the lowest rate of 1.705%.

Table 6. Effect of spraying with iron and boron on two hybrids of broccoli and the interaction between them in the potassium content of the leaves (%)

Hybrid	Treatment				Hybrid average
	0	150mg L^{-1} iron	100 mg L^{-1} boron	(150iron + 100 boron) mg L^{-1}	
Umbrella	1.847	1.946	2.162	2.315	2.067
Jassamine	1.705	1.880	2.003	2.035	1.906
average with iron and boron	1.776	1.913	2.082	2.175	
LSD	0.05				
	0.0534	0.1054		0.1397	

Discussion

The results of the experiment indicated that foliar spraying with chelated iron led to a significant superiority in the studied chemical components of the leaves, represented by the leaf content of carbohydrates, total chlorophyll, and the percentage of nitrogen, phosphorus, and potassium. The reason for the superiority of these components may be attributed to the role of the iron element in the plant and its role in the process of photosynthesis by regulating the process of opening and closing stomata and the content of pigments and antioxidants (Xiao, 2021). The reason for this increase may also be attributed to the role of chelating fertilizers, which have a higher utilization efficiency and without side effects, which work to chelate mineral elements and enhance their ability to be absorbed by the plant(Mhawesh *et al*., 2021).

Boron also has an important structural and physiological role in plants, as it is involved in building cell walls, adding lignin to them, manufacturing RNA nucleic acids, and manufacturing auxin and phenols. It also has an important role in transporting calcium from the root to the leaves and its role in transporting and storing carbohydrates (Mengel, and Appel,2001). thus improving vegetative and physiological growth indicators and the leaves' content of chlorophyll and elements and their carbohydrate content. These results are consistent with (Kassem and El-Kobbia,.2016).

It is also noted that the Umbrella hybrid is superior to the Jassamine hybrid in the chemical components studied, and this may be attributed to the extent to which the hybrid is affected by the existing environmental conditions and the nature of its genetic makeup.

Conclusion

1- The results showed that the Umbrella hybrid significantly outperformed most indicators.

2- The results showed that spraying broccoli plants with iron and boron at concentrations of 100 iron and 150 boron mg/L significantly outperformed most indicators.

3- The two-way interactions between the hybrids at concentrations of 100 iron and 150 boron mg/L showed significant superiority in most indicators.

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