Effect of magnesium fertilization and boron spraying on some growth and yield characteristics of two potato (Solanum tuberosum L.) cultivars

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Abstract

A field experiment was conducted to study the effect of magnesium fertilization and boron spraying on some growth and yield characteristics of two potato cultivars in one of the fields of the College of Agriculture and Forestry/University of Mosul in northern Iraq. The field was divided into 3 panels (each panel represents a replicate) and each field was divided into 24 experimental units. Then, the potato cultivars CARRERA (v1) and PREMABELLE (v2) were planted. Magnesium was added at four levels (0, 40, 80, 120) kg h-1 and the symbols were given (Mg0, Mg1, Mg2, Mg3) respectively, while boron was added at three levels (0, 25, 50) mg l-1 and the symbols were given (B0, B1, B2) respectively. The results showed that the treatment (Mg3) recorded the highest value for plant height, leaf area, number of stems, chlorophyll content and number of tubers, which reached 57.24 cm, 28.6 cm2, 2.86 stems/plant-1, 40.98 SPAD and 9.04 tubers/plant-1, respectively, despite the lack of significant differences between the treatment (Mg3) and other magnesium fertilizer treatments in some characteristics. The treatment (B2) recorded the highest value for plant height, leaf area, number of stems, chlorophyll content and number of tubers, which reached 58.73 cm, 29.0 cm2, 2.84 stems/plant-1, 38.72 SPAD and 9.61 tubers/plant-1. As for the varieties, the variety (v1) outperformed the variety (v2) in the trait of plant height and leaf area, while the variety (V2) outperformed the variety (V1) in the trait of chlorophyll percentage in the leaves, and the varieties did not significantly affect the traits of the number of stems and the number of tubers in the plant.Keywords: Water stress, Zea mays, Physiological, Chlorophyll content.

Introduction

Potatoes are one of the most important crops after wheat, rice and corn, and they also rank first among tuber crops. Potatoes belong to the Solanaceae family, and their cultivation is widespread in large areas of the world, as the area planted with potatoes amounts to 19,463,040 hectares, while the global production of potatoes amounted to 368,096,362 tons. In Iraq, the area used for potato cultivation is estimated at about 42,000 hectares, while its production in Iraq amounts to about 580,000 tons [1].Potato productivity is affected by several factors, the most important of which are climatic factors, soil characteristics, seed sizes, and service operations. Potato varieties differ in yield and tuber size, as a good variety produces a higher yield and larger tubers compared to poor varieties. Tuber maturity also varies from one variety to another. Iraqi potato production is insufficient to meet local consumption, which requires the introduction of new varieties with

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higher productivity and better quality to fill the gap in production[2].Magnesium plays an important role in protein formation and carbohydrate metabolism, increases crop tolerance and resistance to stress, is a major component of chlorophyll pigment and an activator of plant metabolic reactions [3]. Magnesium is also one of the essential nutrients that enhances plant nitrogen uptake and controls many important processes in photosynthesis and production [4] .Boron is a micronutrient that plays an important role in stabilizing some important materials for cell walls, activating cell plasma membranes, enhancing cell division, and differentiating plant tissues. This makes it one of the elements that directly affect cell growth [5]. Boron fertilization increases the net rate of photosynthesis due to the increased chlorophyll content in plant leaves [6]. The research aims to study the effect of magnesium fertilization and boron spraying on some growth and yield characteristics of potato plants.

Material and Methods

Prepare samples:

This study was conducted in one of the agricultural fields affiliated to the College of Agriculture and Forestry, University of Mosul, Nineveh Governorate/Iraq, with the aim of studying the effect of magnesium fertilization and boron spraying on some growth and yield characteristics of the potato cultivars CARRERA and PREMABELLE. Samples were taken from the field soil before planting to study the physical and chemical properties of the field soil. Then the field was divided into three panels (each panel represents a replicate) and each panel was divided into 24 experimental units, each with an area of (3×3) m2, leaving a distance of 1/2 m between the units and a distance of 1.5 m between the replicates. Then, potato tubers were planted in rows, where each experimental unit included 4 rows of 3 m length and 12 tubers in each row (48 tubers in the experimental unit) and a depth of (10-12) cm. Potato seeds were planted manually by manually digging holes in the rows and placing the seeds in them and covering them manually as well. Magnesium sulphate fertilizer MgSO4 (16 MgO) was added at four levels (0, 40, 80, 120) kg ha-1 which were given the symbols (Mg0, Mg1, Mg2, Mg3) respectively. Boron was added by foliar spraying using boric acid H3BO3 (17 boron) at three levels (0, 25, 50) mg l-1 which were given the symbols (B0, B1, B2, B3) respectively and was added in two sprays, the first after 70 days from planting and the second after twenty days from the first spray.

Estimation of physical and chemical properties of soil

The physical and chemical properties of the study soil were estimated as follows:

Soil Texture

It was estimated by the hydrometer method, according to what was stated in [7].pH

The (pH) value was measured in the saturated paste extract of the soil using a pH-meter.

ECe

The (EC) value was measured in the saturated paste extract of the soil using an Ec-meter.

Calcium Carbonate

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It was measured by the gravimetric method using standard hydrochloric acid (3) according to the method mentioned in [10 [

Organic matter (OM(

It was determined by oxidation of organic carbon with potassium dichromate solution $K_2 Cr_2 O_7$, then titration with ferrous ammonia sulphate solution after adding drops of diphenylamine indicator.

studied characteristics

Plant height (cm(

The lengths of the main stems of each plant were measured from the point of stem attachment to the growing tip.

leaf area (cm2(

It was calculated using the Digimizer device, where the fourth leaf was taken from under the growth tip, cleaned from dust, washed well with water, dried and placed on an A4 sheet of paper, with a 10 cm line drawn parallel to one of its edges (A4) as an indication. Then the plant leaf was photographed and the image was transferred to the computer and entered into the Digimizer program [12] Its area was measured.

Number of aerial stems (stem plant -1(

The number of main aerial stems was calculated, then the average number of stems was calculated.

Chlorophyll concentration (Spad (

It was estimated in the leaves using a Spad-502 Chlorophyll meter by taking a number of readings from each plant and then calculating the average [13.[

number of tubers (tuber-plant-1 (

It is calculated by dividing the total number of tubers by the number of selected plants, which is 12 plants.

Statistical analysis

The data were analyzed statistically using the SAS program for the year 2001 and according to Duncan's test at a probability level of 0.05 [14.[

Table 1. Physical and chemical properties of the study soil

No.	Parameters	Value A	Unit
1	Clay	37.525	%
3	Sand	8.525	%
2	Silt	53.950	%
4	Textures	Silty clay loam	-
5	pH	7.98	-
6	EC	0.23	$dS.m^{-1}$
14	$CaCO_3$	21.32	Meq/100g Soil
15	Organic Matter	1.78	%

Results and Discussion

Plant height (cm(

Table (2) shows the effect of magnesium sulphate fertilization, boron spraying, and their interaction on plant height for the two potato varieties CARRERA (V1) and PREMABELLE(V2) . The results showed that there was no significant effect of adding magnesium on potato plant height. The average plant height ranged from 55.87 cm in the Mg0 treatment to 57.24 cm in the Mg3 treatment, while the interaction between the

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varieties and magnesium sulphate fertilization had a significant effect on the average plant height, which ranged from 41.43 cm in the V2Mg0 treatment to 71.44 cm in the V1Mg3 treatment.

As for the effect of foliar spraying with boron on plant height, treatment B2 was superior and recorded the highest value of 58.73 cm compared to treatment B0, which recorded 53.32 cm. As for the interaction between varieties and boron spraying treatments, the results showed that treatment V1B2 was superior, recording the highest average plant height of 75.92 cm compared to treatment V2B0, which recorded 35.63 cm.

Regarding the interaction between magnesium sulphate fertilizer and boron added as a foliar spray, treatment B2Mg3 achieved the highest value for plant height, which is 64.18 cm, compared to treatment B1Mg2, which recorded 48.88 cm. Also, the triple interaction between the varieties, magnesium sulphate fertilizer, and foliar fertilization with boron had a significant effect on plant height, which recorded its highest value of 77.28 cm in treatment V1B1Mg1 and its lowest value of 33.36 cm in treatment V2B0Mg3.

As for the effect of varieties, the results showed that the CARRERA variety was significantly superior in plant height, recording the highest value of 70.10 cm compared to the PREMABELLE variety, which recorded 41.32 cm.

Leaf area (cm2:(

Table (3) shows the effect of magnesium sulphate fertilization and boron spraying and their interaction on leaf area for the CARRERA and PREMABELLE cultivars. The results showed a significant effect of adding magnesium on the average leaf area of the plant, which ranged from 27.5 cm2 in the Mg0 treatment to 29.1 cm2 in the Mg1 treatment. The interaction between the cultivars and magnesium sulphate fertilization also had a significant effect on the average leaf area, which ranged from 23.3 cm2 in the V2Mg1 treatment to 34.8 cm2 in the V1Mg1 treatment.

As for the effect of foliar spraying with boron on plant height, treatment B2 was superior and recorded the highest value of 29.0 cm2 compared to treatment B1 which recorded 27.3 cm2, and regarding the interaction between varieties and boron spraying treatments, treatment V1B2 was superior and recorded the highest average leaf area of 33.7 cm2 compared to treatment V2B2 which recorded 24.3 cm2 .

Regarding the dual interaction between magnesium sulphate fertilizer and boron added as a spray on the leaves, treatment B0Mg0 achieved the highest value of leaf area of 30.5 cm2 compared to treatment B1Mg0 which recorded the lowest average of 23.8 cm2.

Also, the triple interaction between the varieties and magnesium sulphate and foliar fertilization with boron significantly affected the leaf area of the plant, which recorded the highest value of 35.7 cm2 in treatment V1B1Mg1 and the lowest value of 21.3 cm2 in treatment V2B0Mg1.

Regarding the effect of varieties, the CARRERA potato variety outperformed with 32.3 cm2 compared to the PREMABELLE variety, which recorded 24.6 cm2.

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Table 2. Effect of magnesium fertilization and boron spraying on plant height (cm)

varieties	boron fertilization	Magnesium ferlizationti				varieties × Boron	Effect of varieties	Effect of Boron
		M_0	M_1	M_2	M_3			
	B_0	68.75 a	64.52 a b	74.99 a	67.29 a	68.89 a		53.32 b
V_1	B_1	66.24 a	77.28 a	62.32 ab	69.77 a	68.90 a	a 70.10	55.08ab
	B_2	75.92 a	69.07 a	67.80 a	a 77.26	72.51 a		58.73 a
	B_0	35.63 d	46.94 cd	35.06 d	33.36 d	37.75 c		
V_2	B_1	37.93cd	cd 47.05	35.45 d	cd 44.64	41.27 bc	41.32 b	
	B_2	50.73 bc	38.40 cd	39.53 cd	51.10 bc	44.94 b		
varieties * Mg	V_1	70.31 a	70.29 a	68.37 a	71.44 a			
	V_2	41.43b	44.13 b	36.68 b	43.03 b			
Mg * B	B_0	52.19 bc	55.73 c	55.03 abc	50.33 c			
	B_1	52.09 bc	62.17 a b	48.88 c	57.20 abc			
	B_2	63.33 a	53.74 c	53.67 abc	64.18 a			
Effect of Magnesium		55.87 a	57.21 a	52.53 a	a 57.24			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Number of stems (stem plant -1 :(

Table (4) shows the effect of magnesium sulphate and boron spraying and their interaction on the number of stems for the potato varieties CARRERA and PREMABELLE. The results showed that there was no significant effect of magnesium mineral fertilization treatments on the number of stems, which ranged from 2.57 stems plant-1 in treatment Mg1 to 2.86 stems stems plant-1 in treatment Mg3, while the interaction between the varieties and magnesium fertilization treatments had a significant effect on the number of stems, as the highest value

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was recorded, which amounted to 2.94 stems plant-1 in treatment V1Mg0, while the lowest value was recorded, which amounted to 2.36 stems plant-1 in treatment V2Mg1.

As for the effect of foliar spraying with boron, treatment B2 was superior and recorded the highest value of 2.84 stems plant-1 compared to the comparison treatment B0, which recorded the lowest value of 2.48 stems plant-1, with an increase rate of 14.51%. The interaction between the varieties and foliar fertilization with boron also had an insignificant effect on the number of stems, as treatment V1B1 was superior and recorded the highest average number of stems of 2.88 stems plant-1, while treatment V2B0 recorded the lowest value of 2.25 stems plant-1.

Regarding the interaction between magnesium sulphate fertilizer and boron foliar fertilization in the average number of stems, treatment B2Mg2 was superior and recorded the highest value of 3.13 stems plant-1, while the two treatments B0Mg0 recorded the lowest average of 2.21 stems plant-1.

The triple interaction between the varieties, magnesium mineral fertilization, and boron foliar spraying had a significant effect on the average number of stems, as treatment V1B2Mg0 outperformed by recording the highest rate of 3.50 2.21 stems plant-1 compared to treatment V2B0Mg1, which recorded 2.08 2.21 stems plant-1, with an increase rate of 68.27%.

As for the effect of varieties, the results showed no significant differences between them in the number of stems trait, as the CARRERA variety recorded 2.81 stems plant-1, while the PREMABELLE variety recorded 2.60 stems plant-1.

Table 3. Effect of magnesium fertilization and boronspraying on leaf area (cm2)

varieties	boron fertilization	Magnesium ferlizationti				varieties * Boron	Effect of varieties	Effect of Boron
		M_0	M_1	M_2	M_3			
	B_0	33.0 bcd	32.7 bcd	35.3 a	30.7 e	32.93 a		28.9 a
V_1	B_1	22.0 l	35.7 a	31.7 cde	31.3 de	30.18 c	32.3 a	27.3 b
	B_2	33.7 b	36.0 a	31.7 cde	33.3 bc	33.68 a		29.0 a
	B_0	28.0 f	21.3 l	23.3 jk	27.0 fg	24.90 c		
V_2	B_1	25.7 ghi	24.3 ij	22.3 kl	25.3 hi	24.40 c	24.5 b	
	B_2	22.7 gkl	24.3 ij	26.3 gh	24.0 ij	24.33 c		
varieties * Mg	V_1	d29.6 d	34.8 a	32.9 b	31.8 c			
	V_2	25.4 e	23.3 f	24.0 f	25.4 e			
Mg * B	B_0	30.5 a	27.0 e	29.3 ad	28.8 cd			
	B_1	23.8 f	30.0 abc	27.0 e	28.3 d			
	B_2	28.2 d	30.2 ab	29.0 bcd	28.7 d			
Effect of Magnesium		27.5 b	29.1 a	28.4 a	28.6 a			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

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Table 4. Effect of magnesium fertilization and boron spraying on Number of stems (stem plant -1)

varieties	boron fertilization	Magnesium ferlizationti				varieties × Boron	Effect of varieties	Effect of Boron
		Mg_0	Mg_1	Mg_2	Mg_3			
	B_0	2.17 de	3.08 abc	2.42 be	b 3.17 a	2.71 a		2.48 b
V_1	B_1	b 3.17 a	2.83 ae	2.58 be	2.92 ae	2.88 a	2.81 a	2.78 a
	B_2	3.50 a	2.42 be	3.00 ae	2.42 be	a 2.83 a		2.84 a
	B_0	2.25 cde	2.08 e	2.25 cde	2.42 be	2.25 a		
V_2	B_1	2.50 be	2.42 be	2.67 ae	3.17 ab	2.69 a	2.60 a	
	B_2	2.50 be	2.58 be	3.25 ab	3.08 abc	2.85 a		
varieties × Mg	V_1	2.94 a	2.78 abc	2.67 abc	2.83 abc			
	V_2	2.42 bc	2.36 c	2.72 abc	2.89 ab			
Mg × B	B_0	2.21 d	2.58 ad	2.33 cd	2.79 ad			
	B_1	2.83 abc	2.63 ad	2.63 ad	3.04 ab			
	B_2	3.00 ab	2.50 bcd	3.13 a	2.75 ad			
Effect of Magnesium		2.68 a	2.57 a	a2.69	2.86 a			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Chlorophyll content in leaves (SPAD:(

Table (5) shows the effect of magnesium sulphate fertilization and boron spraying and their interaction on the chlorophyll content in the leaves of the potato varieties CARRERA and PREMABELLE, where the mineral fertilization treatment Mg3 outperformed and recorded the highest value of chlorophyll content 40.98 SPAD and an increase of 16.95% compared to the comparison treatment Mg0, which recorded the lowest value 35.04 SPAD. The interaction between the varieties and magnesium fertilization also had a significant effect on the chlorophyll content in the plant, where the V2Mg3 treatment outperformed and recorded the highest value of chlorophyll content in the leaves 41.24 SPAD compared to the V1Mg0 treatment, which recorded the lowest value 32.79 SPAD. Regarding the effect of spraying with boron, treatment B2 was superior by giving the highest average chlorophyll percentage of

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38.72 SPAD and an increase of 4.59% compared to the comparison treatment B0 which recorded 37.02 SPAD.

As for the effect of the varieties, the PREMABELLE variety was significantly superior in the average chlorophyll percentage and recorded the highest value of 39.00 SPAD compared to the CARRERA variety which recorded 36.90 SPAD.

the interaction between magnesium sulphate fertilizer and boron foliar fertilization in chlorophyll content, treatment B2Mg3 was superior and recorded the highest value of 43.97 SPAD compared to treatment B0Mg0, which recorded the lowest value of the trait of 29.52 SPAD.

The triple interaction between mineral fertilization treatments and boron spraying had a significant effect on the chlorophyll trait in leaves, as treatment V2B2Mg3 outperformed and recorded the highest value for the trait, reaching 45.53 SPAD, while treatment V1B0Mg0 recorded the lowest value, reaching 24.47 SPAD.

Table 5. Effect of magnesium fertilization and boron spraying on Chlorophyll content in leaves (SPAD)

varieties	boron fertilization	Magnesium ferlizationti				varieties * Boron	Effect of varieties	Effect of Boron
		Mg_0	Mg_1	Mg_2	Mg_3			
V_1	B_0	24.47m	37.77 cf	35.03 il	44.43 ab	35.43 d	36.90 b	37.02 b
	B_1	40.40 cde	36.27 hk	37.50 gj	35.30 il	37.37 c		38.13 a
	B_2	33.50 l	40.07 cf	35.70 hl	42.40 bc	37.92 b		38.72 a
V_2	B_0	34.57 kl	42.40 bc	35.37 il	42.10 c	38.61 ab	39.00 a	
	B_1	39.30 dg	40.50 cd	39.63 dg	36.10 hk	38.88 ab		
	B_2	38.03 eg	35.53 il	38.97 dg	45.53 a	39.52 a		
varieties × Mg	V_1	32.79 e	38.03 c	36.08 d	40.71 a			
	V_2	37.30 a	39.48 b	37.99 c	41.24 a			
Mg × B	B_0	29.52 f	40.08 b	35.20 e	43.27 a			
	B_1	39.85 bc	38.38 cd	38.57 bcd	35.70 e			
	B_2	35.77 e	37.80 d	37.33 d	43.97 a			
Effect of Magnesium		35.04 d	38.76 b	37.03 c	40.98 a			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Number of tubers per plant (tuber plant-1 :(

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Table (6) shows the effect of fertilizing with magnesium sulphate and spraying with boron and the interaction between them on the average number of tubers for the potato varieties CARRERA and PREMABELLE, as the addition of magnesium fertilizer led to a significant increase in the average number of tubers, which ranged from 8.32 tubers plant-1 in the Mg0 treatment to 9.04 tubers plant-1 in the Mg3 treatment, with an increase rate of 8.65%.

The interaction between varieties and mineral fertilization treatments had a significant effect on the average number of tubers, as treatment V2Mg3 outperformed and recorded the highest value of 9.14 tubers plant-1, while treatment V1Mg0 recorded the lowest value of 8.08 tubers plant-1.

As for the effect of boron, treatment B2 was superior by giving the highest value for the average number of tubers, which amounted to 9.61 tubers/plant-1, with an increase rate of 21.80% compared to the comparison treatment B0, which recorded the lowest average, which amounted to 7.89 tubers plant-1.

Regarding the interaction between varieties and boron spray treatments, treatment V2B2 recorded the highest average number of tubers, reaching 10.00 tubers plant-1, compared to treatment V1B0, which recorded the lowest average, reaching 7.81 tubers plant-1. The interaction between magnesium fertilization and boron foliar spraying had a significant effect on the average number of tubers, which ranged from 7.13 tubers plant-1 in treatment B0Mg0 to 10.25 tubers plant-1 in treatment B2Mg3.

The triple interaction between varieties, soil fertilization with magnesium and foliar spraying with boron had a significant effect on the average number of tubers, as treatment V2B2Mg3 outperformed and recorded the highest value for the trait, reaching 10.92 tubers plant-1, while treatment V1B0Mg0 recorded the lowest value for the trait, reaching 6.58 tubers plant-1. As for the varieties, the results showed that there was no significant effect on the number of tubers trait, as the CARRERA variety recorded 8.65 tubers plant-1, while the PREMABELLE variety recorded a lower value, reaching 8.64 tubers plant-1.

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Table 6. Effect of magnesium fertilization and boron spraying on Chlorophyll content in leaves (SPAD)

varieties	boron fertilization	Magnesium ferlizationti				varieties * Boron	Effect of varieties	Effect of Boron
		Mg_0	Mg_1	Mg_2	Mg_3			
	B_0	6.58 f	8.17 cf	8.67 be	7.83 cf	7.81 c		7.89 b
V_1	B_1	8.50 e	8.83 be	8.83 be	9.42 ad	8.90 b	8.65 a	8.43 b
	B_2	9.17 ae	8.58 be	9.58 abc	9.58 abc	9.23 b		9.61 a
	B_0	7.67 def	8.00 cf	7.33 ef	8.83 be	7.96 c		
V_2	B_1	8.50 be	8.00 cf	7.67 def	7.67 def	7.96 c	8.64 a	
	B_2	9.50 ad	9.25 ad	10.33 ab	10.92 a	10.00 a		
varieties × Mg	V_1	8.08 b	8.53 ab	9.03 ab	b 8.94 a			
	V_2	8.56 ab	8.42 ab	8.44 ab	9.14 a			
Mg × B	B_0	7.13 e	8.08 cde	8.00 de	8.33 cd			
	B_1	8.50 cd	8.42 cd	8.25 cde	8.54 cd			
	B_2	9.33 abc	8.92 bcd	9.96 ab	10.25 a			
Effect of	Magnesium	8.32 b	8.47 ab	8.74 ab	9.04 a			

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

It is noted from the results that magnesium sulfate fertilization had a significant effect on the characteristics of leaf area, chlorophyll percentage in leaves, and the number of tubers in the plant. This is attributed to the role of magnesium fertilization, which led to an increase in the concentration of magnesium in the soil solution and thus increased its absorption by the plant. Magnesium plays an important role in the vital processes of the plant, especially the process of photosynthesis. Magnesium enters into the formation of chlorophyll molecules, as each chlorophyll molecule contains one magnesium atom, and about (15-30)% of total magnesium is associated with the formation of chlorophyll molecules, in addition to the positive role of magnesium in arranging the crana within the chloroplast, which is positively reflected in the processes associated with respiration and photosynthesis [15]. Magnesium also contributes to increasing the activity of many enzymes, thus leading to increased division and elongation of plant cells, which is positively reflected in the indicators of vegetative growth of the plant [16]. These results are consistent with what was mentioned by [17] and [18] who showed that magnesium fertilization has a positive impact

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on the vegetative growth characteristics and yield of potato plants.

As for the effect of spraying with boron, it is noted from the results that spraying with boron had a significant effect on all the studied traits (height, plant, leaf area, number of stems, percentage of chlorophyll in leaves, number of tubers in the plant), and this is attributed to the important role of boron in the formation of cell walls and activation of cell membranes, in addition to its contribution to metabolic processes and its positive role in facilitating the transfer of photosynthesis products from their manufacturing sites in the leaves to other parts of the plant. Boron also has an influential role in cell membranes, which lies in the absorption of other nutrients such as nitrogen, potassium and phosphorus, which have a significant impact on plant growth and regulation of its vital activities [19]. Boron also improves the physiological and biochemical processes of the plant by increasing the activity of meristematic tissues and increasing the division and elongation of plant cells. Boron also plays a role in the production, regulation and preparation of auxin in the plant, which enhances growth characteristics. The green and the yield [19] and [20], and boron also participates in the manufacture of carbohydrates, which helps in the division of plant cells, and this is positively reflected in the growth indicators and yield, and these results are consistent with what was reached by [21] and [22] and [23]

who noted that adding boron as a spray on the potato plant had a positive effect on the growth and yield characteristics of the potato plant

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Conclusion

The results obtained showed that potassium sulphate fertilization had a positive effect on the characteristics of leaf area, chlorophyll percentage, and number of tubers in potato plants, while the characteristics of leaf area and number of stems were not affected by the addition of magnesium sulphate. Spraying with boron also had a positive effect on all the studied characteristics, which are plant height, leaf area, number of stems, chlorophyll percentage in leaves, and number of tubers in the plant.

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