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Effect of foliar feeding with magnesium and manganese on some physiological traits of Faba bean (*Vicia Faba* L.)

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Abstract

During the winter of 2022–2023, a field experiment was conducted in the Al-Majd region of the Al–Muthanna Governorate. to investigate the impact of spraying Faba crop (Luz De Otono) cultivar with four different magnesium concentrations (0, 40, 80, 120 mg Mg l^{-1}) and three different manganese concentrations (0, 20, 40 mg Mn l^{-1}). The experiment was conducted using the R.C.B.D. randomize complete block design with three replications and the factorial experiments inside a split method. The main plots represented the manganese concentrations, while the sub-plots represented the magnesium concentrations. The outcomes demonstrated a considerable impact of magnesium spraying at a concentration of 120 mg Mg l^{-1} on the properties of chlorophyll a, leaf area and its index, and the relative rate of growth, with rates of increase of 31.53%, 36.51%, 36.41%, and 38.70% compared to the comparison treatment. The addition of the higher concentration of manganese led to a significant increase in leaf area, its index, and the relative rate of growth; it gave averages of 4347.25 cm^2, 2.31, and 0.41 g day^{-1} for traits, respectively, compared to the no-spray treatment. The interaction between magnesium and manganese showed a significant effect on the leaf area, as a combination (Mg3 x Mn2) gave the highest average in this trait, amounted to 5701.00 cm^2, and had a significant effect on the leaf area index, and the relative rate of growth, the combination of (Mg3 x Mn1) gave the highest average for the relative rate of growth was 0.56 g day^{-1}.

Keywords: foliar feeding; magnesium; manganese; Faba bean.

Introduction

Faba bean (*Vicia faba* L.) is a winter crop from the legume family Fabaceae. Its seeds contain protein at a high rate ranging from 28-38%, and some varieties contain carbohydrates at a rate of 40-46%, as well as mineral elements, fiber and vitamins. Millions of people in poor countries depend on it as a staple food (1). Foliar feeding is one of the most efficient, most economical methods for treating nutrient deficiencies. Its efficiency increases 8-20 times compared to ground fertilization, especially with microelements (2).

Magnesium is important in synthesising chlorophyll as the center of the chlorophyll molecule. It has a significant role in many physiological processes of the plant as it participates in the formation of the bark and affects the manufacture of proteins and the formation of chromosomes, and is important in activating many enzymes such as (AMP Pyrophosphorylase, Hexokinase and Glucokinase), in addition to its role in increasing Phosphorus uptake and movement within the plant increases plant drought tolerance (3،4).

The importance of manganese comes from its role in regulating the osmotic effort of plant cells and raising the plant's efficiency to resist frost and early flowering, in addition to its role in increasing the percentage of vitamin C. It also activates the enzyme dehydrogenase necessary in the cycle of tricarboxylic acid (TCA). It also works to oxidize indole acetic acid by IAA coenzyme (5). Manganese also contributes to increasing productivity and improving the quality of crops due to its role in many vital processes within the plant, as it plays the role of primary or secondary helper in plant life(6).

Accordingly, the experiment was carried out to know the effect of spraying with magnesium and manganese in determining the best physiological activity that leads to an increase in growth indicators for Faba bean crop.

Materials and Methods

A field experiment was conducted during the winter season (2022/2023) in Al-Majd, a district in a farmer's land in the governorate. To study the role of magnesium and manganese in some physiological characteristics of Faba bean crop.

Using split plots with three replications, the experiment was applied factorially using the randomised complete block design (R.C.B.D.). The plowing, smoothing and levelling process was conducted, and the experimental land was divided according to the design used into experimental units. The area of the experimental unit was (3 x 3 = 9 m), and each experimental unit contained four harrows with a length of 3 m. Seeds were sown on 17 October (7) using a Spanish cultivar (Luz De Otono) on harrows; the distance between them was 75 cm and between one hole and another 25 cm by placing two seeds in each hole. It has germination, but the thinning process was carried out a month after planting by leaving one plant in each hole. After two weeks of planting, the patching process was done for the hols that did not have germination, but the thinning process was carried out a month after planting by leaving one plant in each hole.

As a nitrogen source, urea fertiliser (N46%) was used at a rate of 80 kg NH-1 in two batches, the first two weeks after emergence, and the second batch was added a month after the first batch. As a potassium source, potassium sulphate fertiliser (42%) was used at a rate of 80 kg KH-1 in one batch when planting (6). Phosphorous was added at a rate of 80 kg P-1 in the form of triple superphosphate fertilizer (P21%) and one batch when planting (8). Irrigation and weeding were done whenever needed. Two batches of magnesium were sprayed, the first after a month of planting and the second at the start of flowering. Manganese was sprayed on the field when it had 50% of its flowers. The nutrient solution was mixed with a spreader (cleaning solution) to increase the efficiency of the spray solution by lowering the surface tension of the water and ensuring that the leaves were completely wet. The spraying process was carried out in the early morning using a knapsack sprinkler with a capacity of 16 liters. The only thing that was sprayed during the control treatment was distilled water.

Before planting, random samples from the experimental field were examined physically and chemically using a depth range of 0 to 30 cm, as shown in (Table 1).

Table (1) Some physical and chemical characteristics of the experimental field before planting			
Trait		Value	Unit
pH		7.82	
E.C (1:1)		4.30	des m^{-1}
Available N		28.00	mg kg $soil^{-1}$
Available P		9.8	
Available K		195	
Available Mg		180	
Available Mn		1.17	
Soil articulations	Clay	15.68	g kg^{-1}
	Silt	73.52	
	Sand	10.80	
Soil texture		Silty Loam	

Studied traits

1- Chlorophyll A: Chlorophyll A was estimated at the beginning of the formation of pods by weighing 0.5 g of fresh leaves that were randomly taken from the fifth leaf (the leaf whose direction is opposite to the sun). It was randomly chosen from the two middle centers for each experimental unit, and then it was crushed with 10 ml of acetone. A concentration of 80% to extract the dye, then complete the volume to 20 ml using distilled water, and then a spectrophotometer estimated the chlorophyll dye at a wavelength of (663) and (645) nanometers, and then according to the concentration of chlorophyll A according to the following equation (9):

Chlorophyll a (mg/L)= [12.9(O.D 663)] − [2.69(O.D 645)]

2- Chlorophyll b (mg 100 g-1)

According to the concentration of chlorophyll B according to the following equation (9):

Chlorophyll b (mg/L) = [22.9(O.D 645)] − [4.68 (O.D 663)]

3- Leaves content of total chlorophyll:

The total chlorophyll pigment was estimated according to the following equation (9):

Total Chlorophyll (mg/L) = [20.2(O.D645)] + [8.02 (O.D 663)]

4- Leaf area (cm^2): It represents the average of five plants from each experimental unit, which were chosen randomly from the two middle centers, and the leafy area of each plant was measured by taking three leaves from each plant and measuring the dimensions of each leaf, and then entering it into the following equation: -

LA=0.04+0.45(LW)

Then calculated its mean and multiplied by the number of plant leaves (10).

5- Leaf area index: It is considered a measure of morphological significance, representing the ratio between the area of leaves that a plant bears about the area of land occupied by this plant, and it was calculated according to the following equation (11):-

LAI = Leaf area (LA) /Ground area (Ga)

6- The relative growth rate: It was calculated by drying two plants from each experimental unit and drying them. After 60 days of taking the plants of the first batch, samples of the second batch, represented by three plants from each experimental unit, were taken and dried according to their average and their weight was measured, then after that extract the relative rate of growth according to the following equation (11):

Relative rate of growth = Log W2 - Log W1 / T2 - T1

Statistical analysis:-

The arithmetic means were compared using the L.S.D test at the probability level of 0.05 and the data were analysed in accordance with the experiment's design using the GenStat analysis programme (12).

Results and Discussion

Chlorophyll a (mg 100g^{-1})

It was observed from Table (2) that there was a significant increase with the increase in magnesium concentration, as the higher concentration Mg3 gave the highest average for this characteristic, amounting to 19.27 mg 100 g^{-1} compared to the non-spraying treatment Mg0 which gave the lowest average of 14.65 mg 100 g^{-1}. It may be due to The reason that magnesium occupies the center of the chlorophyll molecule, as magnesium constitutes 2.7% of the weight of the chlorophyll molecule, as it participates with nitrogen in the formation of chlorophyll, and increasing its concentration in the spray solution led to an increase in chlorophyll (a), and thus played an important role in the photosynthesis process, which is based on the chlorophyll molecule. At the same time, there was no significant effect of manganese and the interaction between the two factors in this characteristic.

Table (2) The role of spraying with magnesium and manganese and their interaction in chlorophyll a (mg 100 g^{-1})

Magnesium / Manganese	Mg_0	Mg_1	Mg_2	Mg_3	Average Mn
Mn_0	15.21	16.94	18.64	19.51	17.57
Mn_1	12.72	13.52	16.97	16.08	14.82
Mn_2	16.03	14.51	21.28	22.23	18.51
Average Mg	14.65	14.99	18.96	19.27	
L.S.D (0.05)	Mg		Mn		Mg x Mn
	2.81		N.S		N.S

Chlorophyll b (mg 100g^{-1})

The statistical analysis results indicated no significant differences when spraying with magnesium and manganese and the interaction between them in the characteristic of chlorophyll b (Table 3).

Table (3) The role of spraying with magnesium and manganese and their interaction in Chlorophyll b (mg $100g^{-1}$)

Magnesium / Manganese	Mg0	Mg1	Mg2	Mg3	Average Mn
Mn0	6.86	14.47	10.00	12.01	10.83
Mn1	9.51	14.58	21.25	14.84	15.05
Mn2	10.52	14.06	14.27	15.37	13.56
Average Mg	8.96	14.37	15.17	14.07	
L.S.D (0.05)	Mg		Mn		Mg x Mn
	N.S		N.S		N.S

Leaves content of total chlorophyll (mg $100g^{-1}$)

When spraying magnesium, Table (4) demonstrated that there were significant differences in this characteristic. The third concentration, Mg2, produced the highest average of 36.57 mg 100 g-1, which was comparable to the fourth concentration, Mg3, which produced an average of 36.54 mg 100 g-1. Mg0 had the lowest mean from the comparative treatment, 22.81 mg 100 g-1. It is possible that magnesium spraying increased chlorophyll (a) (Table 2), which in turn increased total chlorophyll, which resulted in an increase in the chlorophyll content of the leaves. The crucial enzymes involved in creating and synthesising the chlorophyll molecule are among them, and this increased the amount of chlorophyll in the leaves (13).

Table (4) the role of spraying with magnesium and manganese and their interaction in total chlorophyll (mg 100 g^{-1})

Magnesium / Manganese	Mg0	Mg1	Mg2	Mg3	Average Mn
Mn0	18.02	32.17	34.47	39.63	31.07
Mn1	23.08	28.93	38.98	31.71	30.67

Mn2	27.34	29.38	36.25	38.28	32.81
Average Mg	22.81	30.16	36.57	36.54	
L.S.D (0.05)	Mg		Mn		Mg x Mn
	4.88		N.S		N.S

Leaf area cm^2

The results in Table (5) indicated that the leaf area increased with increasing magnesium concentration, as the highest concentration, Mg3 achieved the highest average of 4156.33 cm^2, which did not differ significantly from the third concentration, Mg2, which gave an average of 4041.66 cm^2. The comparison treatment gave the lowest average for this characteristic of 3044.66 cm^2. Perhaps the increase when spraying with magnesium is due to its important role in activating many enzymes that contribute to vital processes, being an important part of chlorophyll. It led to an increase in the leaves' content of total chlorophyll (Table 4), which is the primary substance in the photosynthesis process, so it has a role in increasing The process of photosynthesis, which contributes to increasing the outputs of this process, which leads to an increase in the leaf area.

The results of Table (5) also showed a significant effect when spraying with manganese on the leafy area, as the higher concentration exceeded Mn2 and gave the highest average of 4347.25 cm^2 compared to the no-spray treatment, which gave an average of 3510.75 cm^2. The reason may be attributed to the role of manganese in building an efficient root system. It is high in the absorption of nutrients and water, thus providing a store of food supply, and this contributes to reducing the state of competition within a single plant and between plants, which provides good growth and leads to an increase in leafy area (14), and this result agreed with (15) who showed that Spraying with manganese increased the leaf area. The interaction between the two factors of the study, magnesium and manganese, also significantly affected the paper area, as the higher concentration of magnesium exceeded Mg3 with the higher concentration of manganese Mn2, represented by the combination (Mg3 x Mn2), which gave the highest average of 5701.00 cm^2. In contrast, the combination gave (Mg0 x Mn1), represented by the comparison treatment. The lowest average for magnesium Mg0 with the second concentration of manganese Mn1 was 2135.00 cm^2.

Table (5) the role of spraying with magnesium and manganese and their interaction in leaf area cm^2

Magnesium / Manganese	Mg0	Mg1	Mg2	Mg3	Average Mn
Mn0	3081.00	3510.00	4113.00	3339.00	3510.75
Mn1	2135.00	3628.00	3980.00	3429.00	3293.00
Mn2	3918.00	3738.00	4032.00	5701.00	4347.25
Average Mg	3044.66	3625.33	4041.66	4156.33	
L.S.D (0.05)	Mg		Mn		Mg x Mn
	594.50		837.10		1089.80

area index when spraying with manganese, as the third concentration, Mn2, gave the highest average of 2.31, with an increase of 23.52% compared to the comparison treatment, Mn0, which gave the lowest average of 1.87. This result agreed with the leaf area (Table 5) (15).

The interaction between magnesium and manganese had a significant effect on this characteristic, as it gave the highest concentration of

Leaf area index

The results of Table (6) showed that there was a significant effect when spraying with magnesium, as the fourth concentration, Mg3, achieved the highest rate in the leaf area index of 2.21 compared to the comparison treatment, which gave the lowest average of 1.62 Table (5), which reflected positively on the index of paper space and led to its increase. The results of Table (6) showed a significant increase in the leaf concentration of manganese, Mn1, the lowest mean for this characteristic was 1.13. Perhaps the reason for the superiority of the higher concentration of the two factors is due to their superiority in increasing the leaf area (Table 5), which led to an increase in the leaf area index.

magnesium Mg3 with the highest concentration of manganese Mn2, represented by the combination (Mg3 x Mn2), the highest mean of leaf area index reached 3.04, while the combination (Mg0 x Mn1), represented by the non-spray treatment of magnesium, gave Mg0 With the second

Table (6) the role of spraying with magnesium and manganese and their interaction in leaf area index

Magnesium / Manganese	Mg0	Mg1	Mg2	Mg3	Average Mn
Mn0	1.64	1.87	2.19	1.78	1.87
Mn1	1.13	1.93	2.12	1.82	1.75
Mn2	2.09	1.99	2.15	3.04	2.31
Average Mg	1.62	1.93	2.15	2.21	
L.S.D (0.05)	Mg		Mn		Mg x Mn
	0.31		0.44		0.58

Relative rate of growth (g day^{-1})

It was observed from Table (7) that there was a significant increase in the relative rate of growth with the increase in the concentration of magnesium, as the higher concentration of magnesium Mg3 recorded the highest average in the relative rate of growth, amounted to 0.43 g on day^{-1} compared to the concentration of Mg0 which gave the lowest average of 0.31 g on day^{-1}. Perhaps the reason is due to the physiological role of magnesium in increasing the leaf area (Table 5) and its evidence (Table 6), which contributed to raising the efficiency of photosynthesis and the transfer of the products of this process, which led to an increase in the growth of the crop.

Spraying with manganese also had a significant effect on the relative rate of growth, as the highest concentration exceeded Mn2, which gave the highest average of 0.41 g on day^{-1}, while the treatment of spraying with distilled water only gave the lowest average for this characteristic, amounting to 0.32 g on day^{-1}, and perhaps the reason for the increase in the rate of Relative growth to the role of manganese as a stimulant and a catalyst for the abundance of enzymes in the plant in addition to being an essential micronutrient for plant growth and development as it enhances the metabolic components within the different plant cell divisions (16).

The interaction between magnesium and manganese, the higher concentration of magnesium Mg3 was recorded with the second concentration of manganese Mn1. The combination (Mg3 x Mn1) had the highest average relative growth rate of 0.56 g day-1, while the two combinations (Mg0 x Mn1) and (Mg1 x) recorded Mn0, which gave the lowest mean for this trait, was 0.22 gm on day^{-1}.

Table (7) the role of spraying with magnesium and manganese and their interaction in the relative rate of growth g day^{-1}

Magnesium / Manganese	Mg0	Mg1	Mg2	Mg3	Average Mn
Mn0	0.32	0.22	0.45	0.28	0.32
Mn1	0.22	0.36	0.38	0.56	0.38
Mn2	0.39	0.51	0.30	0.43	0.41
Average Mg	0.31	0.36	0.37	0.43	
L.S.D (0.05)	Mg		Mn		Mg x Mn
	0.07		0.05		0.11

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