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BIOMASS PRODUCTION AND MACRONUTRIENTS UPTAKE BY FABA BEAN (*VICIA FABA L.*) PLANTS GROWN ON SANDY SOIL IN RESPONSE TO FOLIAR AND FERTIGATION OF BORON AND MAGNESIUM APPLICATION

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ABSTRACT: A pot experiment was conducted using sandy loam soil collected from Quesna, Menoufia Governorate, Egypt, to evaluate the effects of magnesium (Mg) and boron (B) applied through foliar spraying and fertigation on faba bean (*Vicia faba* L.). Treatments included three levels of Mg (as Mg SO_4) and B (as boric acid), supplied individually and in combination, in addition to a control. Plant growth was assessed at 45 days by measuring fresh matter yield (FMY), dry matter yield (DMY), and macronutrient uptake (N, P, K).

The results showed that applying Mg and B, either individually or in combination, significantly increased biomass production and nutrient accumulation compared to the control. The interaction between Mg and B led to an increase in the assimilation of N, P, and K, which in turn improved the growth and yield. The highest combined foliar treatment (B3Mg3) increased N uptake to 143.07 mg pot^{-1} (relative increase (RI) = 252%), P uptake to 42.08 mg (RI = 231%), and K uptake to 65.75 mg (RI = 241%) at 45 days. Fertigation (B_3Mg_3) resulted in strong responses, including N uptake of 131.10 mg pot^{-1} (RI = 213%), P uptake of 40.48 mg pot^{-1} (RI = 195%), and K uptake of 60.72 mg pot^{-1} (RI = 203%). The most intensive combined treatments resulted in RI levels exceeding 100%, as FMY and DMY followed a similar pattern. In general, foliar application had a greater impact than fertigation, although both methods significantly enhanced growth and nutrition compared to the control.

The study highlights the importance of integrating foliar and fertigation approaches for optimizing Mg and B nutrition in faba bean cultivated on Egyptian sandy soils, offering a pathway to enhance productivity and resource-use efficiency in reclaimed lands.

Keywords: Faba bean (*Vicia faba L.*), sandy soils, boron, magnesium, foliar application, fertigation, nutrient uptake.

INTRODUCTION

Sandy soils in Egypt are characterized by low fertility, weak nutrient retention, and high leaching losses, which constrain crop productivity and nutrient-use efficiency. Faba bean (*Vicia faba L.*) is a significant winter legume in Egypt, renowned for its high protein content and its contribution to soil fertility through biological nitrogen fixation. However, its productivity in sandy soil is often limited by nutrient deficiencies. Magnesium and boron are two essential nutrients involved in photosynthesis, carbohydrate transport, nodulation, and reproductive development. Efficient application methods are therefore needed to improve nutrient uptake and biomass accumulation under these conditions.

Sandy soils dominate extensive areas of Egypt's reclaimed lands, particularly in arid and semi-arid zones such as the Western Desert, Sinai, and the fringes of the Nile Delta. These soils are distinguished by their coarse texture, low organic matter content, and minimal cation exchange capacity (CEC), all of which contribute to poor water and nutrient retention (Elkhouly *et al.*, 2021; Huang & Hartemink, 2020). As a result, nutrients such as nitrogen (N), Mg, and B are readily leached beyond the root zone, reducing fertilizer-use efficiency and ultimately constraining crop productivity (Blanchart *et al.*, 2005; Elbana *et al.*, 2019). Managing soil fertility under such conditions is therefore one of the foremost challenges to sustainable crop production in Egyptian sandy soils.

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Faba bean (*Vicia faba L.*) is one of the most important winter legumes cultivated in Egypt. It is widely recognized as a staple food crop due to its high protein content, as well as for its role in improving soil fertility through biological nitrogen fixation (Mínguez & Rubiales, 2021; Abdelrahman *et al.,* 2023). In addition to its nutritional and agronomic value, faba bean is economically important, given that Egypt is currently the world's largest importer of faba beans, relying heavily on imports from Australia and Europe (FAO, 2023). Enhancing domestic faba bean productivity, particularly in reclaimed sandy soils, is therefore a national priority. However, yields are often limited by nutrient imbalances and deficiencies that impair biomass accumulation, nodulation, and pod development (Fahmy *et al.*, 2024; Shaban *et al.*, 2023).

Two vital nutrients crucial to plant metabolism and yield formation are Mg and B. The key component of the chlorophyll molecule, Mg, is essential for protein synthesis, photosynthesis, and the partitioning of carbohydrates (Marschner, 2012; Cakmak & Kirkby, 2021). Its adequate supply has been shown to increase biomass accumulation by enhancing light use efficiency, improving N assimilation, and stimulating P uptake. In legumes, magnesium nutrition supports nodule formation and nitrogen fixation, while also regulating carbon transport to developing seeds (Peng *et al.,* 2018; Gaber *et al.,* 2024). Conversely, Mg deficiency in sandy soils is common due to its moderate mobility and antagonistic competition with calcium and potassium, which often leads to reduced photosynthesis, chlorosis, and yield losses (Guo *et al.,* 2016; Abdelgawad *et al.,* 2020).

Boron, although required in smaller amounts, is equally vital for plant growth. It contributes to cell wall structure, membrane stability, sugar transport, and reproductive development (Bolaños *et al.,* 2023). In legumes, B is vital for nodulation and nitrogen fixation by Rhizobium, as well as for effective seed set and pod development (Shorrocks, 1997; Liu *et al.,* 2024). Deficiency symptoms such as brittle leaves, flower abortion, and poor seed filling are common in Egyptian sandy soils due to high leaching and alkaline soil conditions that restrict B solubility (Goldberg, 1997; Youssef & Siam, 2018). Importantly, Mg and B have been reported to act synergistically: Mg enhances photosynthetic capacity and assimilate transport, while B ensures efficient carbohydrate allocation to reproductive organs. Together, their balanced supply has been linked to improved accumulation of N, P, and carbon compounds, thereby promoting higher biomass and yield (Abedini *et al.*, 2024).

In sandy soils, characterized by limited nutrient retention and frequent leaching, the method of nutrient application is a crucial factor influencing fertilizer-use efficiency. Fertigation, the application of soluble fertilizers via irrigation water, provides an efficient method for delivering nutrients directly to the root zone while minimizing leaching losses (Shalaby et al., 2016). This technique allows synchronization of nutrient supply with crop demand and is especially valuable under sandy soil conditions where frequent irrigation is already necessary. Fertigation with Mg and B has been shown to enhance nutrient uptake and improve crop performance compared with conventional soil application (Abd El-Rahman *et al.,* 2018).

Foliar application provides a complementary strategy, delivering nutrients directly to plant leaves where they can be rapidly absorbed and redistributed to growing tissues (Erdal *et al.,* 2016). This method is beneficial for correcting deficiencies during critical growth stages, such as flowering and pod filling, when nutrient demand is high, but soil supply is constrained. Studies in legumes and other crops under arid and semi-arid conditions have demonstrated that foliar sprays of Mg and B significantly increase chlorophyll content, improve N and P uptake, and enhance dry matter production (Mohamed & Hegab, 2023; Farag *et al.*, 2025). By bypassing soil limitations such as high pH and low CEC, foliar feeding ensures efficient utilization of these nutrients.

Thus, integrating fertigation and foliar feeding of Mg and B represents a promising strategy for improving faba bean productivity in Egypt's sandy soils. This dual approach has the potential to enhance nutrient-use efficiency, biomass accumulation, and seed yield under the challenging conditions of reclaimed desert lands. The present study was therefore undertaken to evaluate the impact of magnesium and boron applied through foliar spray and fertigation on growth performance, biomass production, and macronutrient (N, P, K) uptake of faba bean grown in sandy soils.

MATERIALS AND METHODS

A pot experiment was conducted in the greenhouse of the Department of Soil Science, Faculty of Agriculture, Shibin El-Kom, Menoufia University, Egypt, in late December 2020 to investigate the impact of the interaction between boron and magnesium, applied via two distinct methods (foliar and soil application), on the growth and quality of faba bean cultivated in sandy soil. This study utilized 96 plastic pots, each measuring 25 cm in diameter and 20 cm in depth, filled with 5 kg of sieved sandy soil. The used pots were divided into two main groups (48 pots/ group). Surface soil sample (0-30cm) representing sandy soil was collected from a Farm at Quesna, Menoufia Governorate (Latitude: 30.5704° N, Longitude: 31.0145° E). The collected sample was air dried, ground, well mixed, and sieved through a 2mm sieve. A portion of this fine sand was taken to estimate some physical and chemical properties. The content of available nutrients of this soil was determined according to the international method particle size distribution (Kim, 1996), water-holding capacity (Black et al., 1965), and standard chemical properties, including pH, EC, organic matter, soluble ions, and available nutrients. Methods of Page *et al.* (1982), Cottenie *et al.* (1982), and Berger & Truog (1939) were followed. The obtained data were recorded in Table 1.

Table 1: Some physical and chemical properties of the tested soil.

Property	**Value**	**Unit / Method**
Particle Size Distribution		
Clay	8.95	%
Silt	12.98	%
Fine Sand	63.34	%
Coarse Sand	14.73	%
Texture	Sandy loam	USDA classification
Water holding capacity	18.6	cm^3 water/cm^3 soil (vol%)
Chemical Properties		
pH	7.70	1 soil :2.5 water (suspension)
EC	1.02	dS/m (1soil:5 water extract)
Organic Matter	0.60	% (Walkley–Black method)
Soluble Cations		meq L^{-1} (1:5 extract)
Ca^{2+}	3.18	
Mg^{2+}	2.22	
Na^{+}	3.84	
K^{+}	1.02	
Soluble Anions		meq L^{-1} (1:5 extract)
HCO_3^{-}	3.42	
Cl^{-}	4.26	
SO_4^{2-}	2.58	
Available Nutrients		
N	21.3	mg/kg (KCl extract)
P	9.6	mg/kg (Olsen method)
K	122	mg/kg (NH_4 OAc extract)
Mg	47.5	mg/kg (NH_4 OAc extract)
B	0.34	mg/kg (Hot water extract)

Seeds of faba bean (*Vicia faba L.*) Giza 843cv., were brought from the Crops Institute Research, Agricultural Research Center (ARC), Egypt. Before planting, all treatments received a recommended dose of P and were mixed well with the sandy soil. The pots of each leading group were divided into 16 subgroups (16 pots/subgroup) representing the treatments of B and Mg. The studied treatments were arranged in a plot in a split design with six replicates. Each pot was cultivated with four seeds of faba bean thinned to 3 plants after 10 days of sowing. The moisture content of the cultivated pot was maintained at 60% of its water-holding capacity using tap water. After 20 days of sowing and with irrigation water, all pots were fertilized by N and K fertilizers in the form of ammonium nitrate NH_4NO_3 (N 33%) and potassium sulfate K_2SO_4 (K_2O 48%) in 50 and 100 kg fed^{-1} (0.25 and 0.5g pot $^{-1}$), respectively. Magnesium sulfate ($MgSO_4.7H_2O$) and Boric acid (H3BO3) were applied as sources of Mg and B at different rates. Two methodologies for application were employed: Foliar application was conducted at rates of 0, 3, 5, and 10 kg ($MgSO_4.7H_2O$) per 400 L of water per hectare. A concentration of 0-1.3–1.95 and 2.6 kg (H_3BO_3) per 400 liters of water is administered. Fertigation applications at rates of 0, 50, 70, and 100 kg ($MgSO_4.7H_2O$) per acre. 0 – 1.3 – 1.95 and 2.6 kg (H_3BO_3) per hectare. The descriptions of Mg and B treatments are provided in Table 2.

Table 2: Description of B and Mg treatments applied to Faba Bean Plants via fertigation and Foliar application.

Treatment	Application method	
	Foliar	Fertigation
	Concentration of applied treatment	
Control	Control (without boron or magnesium application)	Control (without boron or magnesium application)
B1	B1: 160 mg/L	B1: 320 mg/L
B2	B2: 325 mg/L	B2: 486 mg/L
B3	B3: 487 mg/L	B3: 650 mg/L
Mg1	Mg1: 2.5 gm / L	Mg1: 0.75 gm / L
Mg2	Mg2: 3.5 gm / L	Mg2:1.25 gm / L
Mg3	Mg3: 5 gm / L	Mg3: 2.5 gm / L
B1Mg1	B1: 160 mg/L + Mg1: 2.5 gm / L	B1: 320 mg/L + Mg1: 0.75gm / L
B1Mg2	B1:160 mg/L + Mg2 :3.5gm/L	B1: 320 mg/L + Mg2: 1.25 gm / L
B1Mg3	B1: 160 mg/L + Mg3: 5 gm / L	B1: 320 mg/L + Mg3: 2.5 gm / L
B2Mg1	B2: 325 mg/L + Mg1: 2.5gm / L	B2: 486 mg/L + Mg1: 0.75gm / L
B2Mg2	B2: 325 mg/L + Mg2: 3.5 gm / L	B2: 486 mg/L + Mg2: 1.25 gm / L
B2Mg3	B2: 325 mg/L + Mg3 :5 gm / L	B2: 486 mg/L + Mg3: 2.5 gm / L
B3Mg1	B3: 487 mg/L + Mg1: 2.5gm / L	B3: 650 mg/L + Mg1: 0.75gm / L
B3Mg2	B3: 487 mg/L + Mg2: 3.5 gm / L	B3: 650 mg/L+ Mg2: 1.25 gm / L
B3Mg3	B3 :487 mg/L +Mg3: 5 gm / L	B3: 650 mg/L+ Mg3: 2.5 gm / L

One plant of each treatment was cut after 45 days of planting on the 10th of February. The fresh weight of all plants was recorded, then air-dried, oven-dried at 70˚C, maintained at a constant weight, and preserved for analysis. Dried plant tissues (shoots) were digested using a H_2SO_4 –$HClO_4$ mixture (3:1 v/v) following Chapman & Pratt (1961). The digests were analyzed for: Nitrogen by the Kjeldahl method (Page *et al.,* 1982), Phosphorus by spectrophotometry (Olsen *et al.,* 1954), and Potassium by flame photometry (Page *et al.,* 1982). The mineral status of faba bean plants was evaluated not only in terms of nutrient concentrations in plant tissues, but also in terms of nutrient uptake and relative increase (RI), which measures the total amount of a given element accumulated by the plant. Nutrient uptake was calculated as a product of nutrient concentration and dry matter yield per plant, using the following formulas:

$$RI = \frac{\text{value of treatment} - \text{value of control}}{\text{value of control}} \times 100$$

Uptake (mg.pot^{-1}) =

Dry matter (g.pot^{-1}) × Concentration (%) ×10

The data were analyzed using analysis of variance as described by Snedecor and Cochran (1980). The statistical analysis was done using the Costat package program, version 6.4 (Cohort software, USA). The differences among the means of the different treatments were tested using the least significant difference (LSD) at a 5% probability.

RESULTS AND DISCUSSION

Growth parameters

The presented data in Table 3 elucidate both individual and combined applications of B and Mg in two application methods, foliar and soil application, on fresh and dry matter yields (g pot^{-1}) of faba bean plants. This effect was studied during two growth periods, 45 days after planting, under greenhouse conditions. In general, all applications increased both FMY and DMY of faba bean plants (g pot^{-1}). These increases varied widely depending on the studied treatment and growth period, as shown from the values of RI (%) of FMY and DMY affected by the studied treatment compared with the data of the control treatment, where all RI values were positive.

Table 3: Effect of B and Mg application on FMY and DMY yields of faba bean plants (g pot $^{-1}$) at 45 days and their RI (%)

Treatment	Application method							
	Foliar				Fertigation			
	FMY		DMY		FMY		DMY	
	g pot^{-1}	RI%	g pot^{-1}	RI%	g pot^{-1}	RI%	g pot^{-1}	RI%
Control	17.20	0.00	2.54	0.00	17.20	0	2.54	0
B1	18.43	7.15	2.78	9.54	17.60	2.33	2.71	6.69
B2	18.80	9.30	2.98	17.32	19.03	10.64	3.14	23.62
B3	20.00	16.28	3.20	25.99	19.40	12.79	3.68	44.88
Mg1	18.70	8.72	2.85	12.20	18.80	9.30	2.87	12.99
Mg2	19.40	12.79	2.99	17.72	19.07	10.87	3.35	31.89
Mg3	19.70	14.53	3.18	25.20	20.33	18.20	3.75	47.64
B1Mg1	19.77	14.94	3.32	30.71	20.00	16.28	4.21	65.75
B1Mg2	21.33	24.01	3.56	40.16	20.97	21.92	3.90	53.54
B1Mg3	21.60	25.58	4.16	81.50	19.96	16.05	3.44	35.43
B2Mg1	20.01	16.34	3.42	34.65	20.87	21.34	4.20	65.35
B2Mg2	22.50	30.81	3.91	53.94	21.50	25.00	3.20	25.98
B2Mg3	22.60	31.40	4.62	81.89	23.20	34.88	3.60	41.73
B3Mg1	21.80	26.74	4.18	64.57	21.80	26.74	3.78	48.82
B3Mg2	22.68	31.86	4.68	84.25	21.96	27.33	4.36	71.65
B3Mg3	22.87	32.97	5.26	107.09	24.23	40.87	4.60	81.10
LSD	0.379*	-	0.436*	-	0.444*	-	0.388*	-

FMY of shoots of faba bean plants at 45 days of growth

Foliar application of B and Mg in Table 3 markedly promoted the FMY of faba bean plants compared with the untreated control (17.20 g pot^{-1}). All single and combined treatments produced statistically significant increases, with RI ranging from 7.15% to 32.97%.

Boron applied individually rose FMY progressively from 18.43 g pot^{-1} in B1 (7.15% RI) to 20.00 g pot^{-1} in B3 (16.28% RI), while Mg added alone enhanced FMY from 18.70 g pot^{-1} in Mg1 (8.72% RI) to 19.70 g pot^{-1} in Mg3 (14.53% RI). It appears that applied B and Mg have a positive effect on stimulating FMY in faba bean plants. These results confirm the vital role of B in cell wall development, sugar transport, and meristematic activity (Shorrocks, 1997), and of Mg in chlorophyll synthesis and enzyme activation (Marschner, 2012), both of which contribute to early vegetative biomass accumulation.

Combined foliar applications of B and Mg consistently outperformed individual applications. The highest yield (22.87 g pot^{-1}; 32.97% RI) was obtained with B3Mg3, followed closely by B3Mg2 (22.68 g pot^{-1}; 31.86% RI) and B2Mg3 (22.60 g pot^{-1}; 31.40% RI) as shown in Fig. 1. This synergistic effect likely reflects the complementary roles of B and Mg in enhancing photosynthetic efficiency, facilitating assimilation and translocation, and promoting structural tissue development (Brown *et al.*, 2002). Notably, the combined treatments not only enhanced FMY but also maintained a balanced vegetative growth pattern, which is critical for sustaining productivity in later stages.

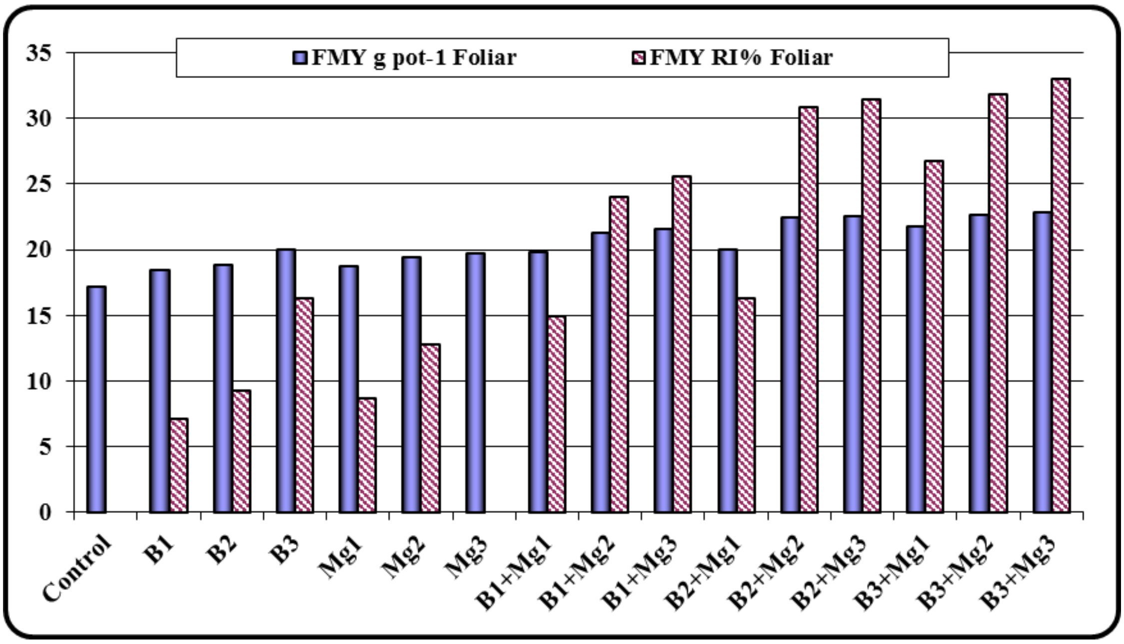

Figure 1: Effect of fertigation treatments of B and Mg on FMY of faba bean plants (g pot $^{-1}$) at 45 days of growth and their RI (%).

The results indicate that foliar application of boron and magnesium significantly influenced the FMY of faba bean plants 45 days after sowing compared with the untreated control. The improvement in FMY under foliar spraying can be attributed to the rapid absorption of micronutrients through the leaf cuticle and stomata, allowing immediate translocation to sites of metabolic activity (El-Fouly *et al.*, 2011). The observed enhancement in vegetative growth and biomass accumulation is therefore linked to improved photosynthate production and partitioning, resulting in increased leaf area and succulent tissues. Treatments combining both nutrients generally surpassed individual applications, reflecting their synergistic effects on physiological and biochemical processes in faba bean plants. These improvements are attributed to B’s role in cell wall integrity, sugar transport, and reproductive tissue development, as well as Mg’s central role in chlorophyll formation and enzymatic activation (Wimmer & Eichert, 2019). Moreover, the superior performance of irrigation-based treatments over foliar ones aligns with findings by Cordeiro *et al.* (2024), who observed more consistent nutrient uptake and improved growth metrics when micronutrients were delivered via soil in coarse-textured soils like sandy loam. The RI for each treatment provides a clear indication of the extent to which fresh and dry biomass improved under each nutrient management approach. These outcomes are especially relevant to sandy soils, which often suffer from nutrient leaching and poor retention capacities (Liu *et al.*, 2023).

The application of B and Mg to faba bean plants significantly increased their FMY compared to the control (17.20 g pot^{-1}), with RI ranging from 2.33% to 40.87%.

For B alone, FMY ranged from 17.60 g pot^{-1} in B1 (2.33% RI) to 19.40 g pot^{-1} in B3 (12.79% RI), reflecting the importance of adequate B supply in promoting cell division, sugar transport, and meristematic growth (Shorrocks, 1997). Similarly, Mg alone increased FMY from 18.80 g pot^{-1} in Mg1 (9.30% RI) to 20.33 g pot^{-1} in Mg3 (18.20% RI), highlighting its central role in chlorophyll formation, photosynthetic activity, and enzyme activation (Marschner, 2012).

Combined fertigation of B and Mg generally produced higher FMY than individual nutrient applications, indicating a synergistic effect on early vegetative biomass. The highest yield (24.23 g pot^{-1}; 40.87% RI) was recorded with B3Mg3, followed by B2Mg3 (23.20 g pot^{-1}; 34.88% RI) and B3Mg2 (21.96 g pot^{-1}; 27.33% RI) as shown in Fig. 2. This synergy likely arises from the combined effects of B on assimilate translocation and Mg on photosynthetic efficiency, leading to greater leaf area expansion, water status maintenance, and accumulation of succulent biomass (Brown *et al.*, 2002).

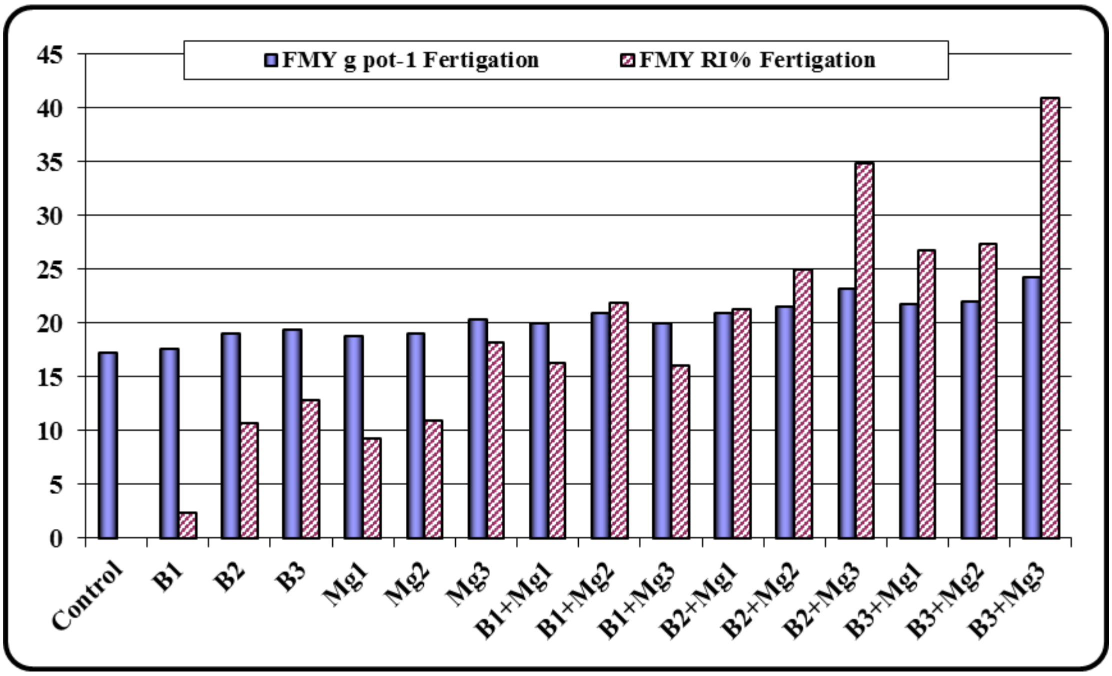

Figure 2: Effect of fertigation treatments of B and Mg on FMY of faba bean plants (g pot $^{-1}$) at 45 days of growth and their RI (%).

Compared with foliar spraying, fertigation showed a slightly slower early-stage response in some treatments, possibly due to the time required for nutrient uptake and translocation from roots to shoots. However, fertigation offers the advantage of sustained nutrient supply in the root zone, which is particularly beneficial in sandy loam soils prone to leaching (FAO, 2017). Such continuous availability supports steady growth, ensuring that plants maintain a high physiological capacity for biomass production throughout the vegetative stage.

DMY of shoots of faba bean plants at 45 days of growth

Foliar application of B and Mg significantly increased the DMY of faba bean plants compared with the untreated control (2.54 g pot^{-1}). The RI ranged from 9.54% in B1 to 107.09% in B3Mg3. Single B treatments resulted in a gradual increase in DMY, from 2.78 g pot^{-1} in B1 (9.54% RI) to 3.20 g pot^{-1} in B3 (25.99% RI). Magnesium alone also improved DMY, reaching 3.18 g pot^{-1} in Mg3 (25.20% RI), Fig. (2 and 4). Combined B and Mg treatments consistently outperformed single applications, with the highest yield recorded in B3Mg3 (5.26 g pot^{-1}; 107.09% RI), followed by B3Mg2 (4.68 g pot^{-1}; 84.25% RI) and B_2Mg_3 (4.62 g pot^{-1}; 81.89% RI) as shown in Fig. 3. This reflects the complementary roles of B in assimilating transport and cell wall stability, and Mg in photosynthetic activity and enzyme function (Shorrocks, 1997; Marschner, 2012). The pronounced increases indicate that foliar feeding rapidly supplies nutrients directly to metabolic sites, accelerating dry biomass accumulation during early growth. The results agree with earlier findings by Al-Jaloud *et al.* (2016), who reported that foliar B and Mg application significantly enhanced early growth parameters in legumes, particularly in sandy soils. The observed improvements in dry matter yield can be attributed to the roles of Mg in chlorophyll biosynthesis and energy transfer, and B in maintaining cell wall structure and facilitating the movement of assimilates. The combination of these two nutrients appears to be particularly beneficial in the early growth period of the faba bean.

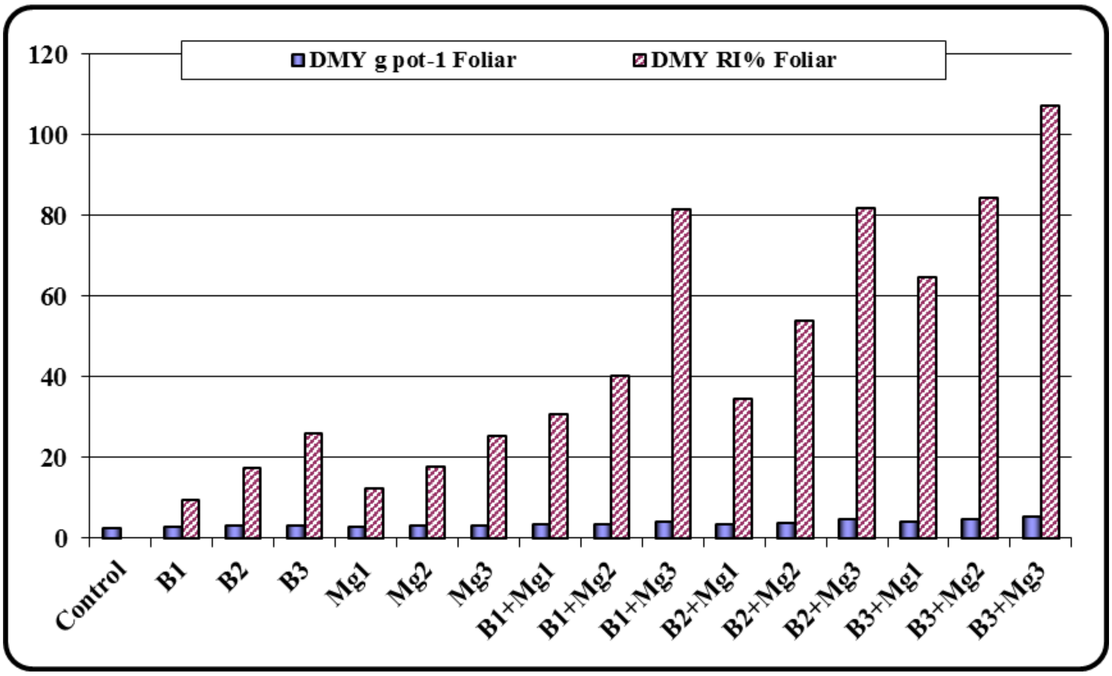

Figure 3: Effect of fertigation treatments of B and Mg on DMY of faba bean plants (g pot $^{-1}$) at 45 days of growth and their RI (%)

Fertigation also significantly enhanced DMY over the control (2.54 g pot⁻ ¹), with RI% ranging from 6.69% in B1 to 81.10% in B3Mg3. Boron alone increased DMY up to 3.68 g pot⁻ ¹ in B3 (44.88% RI), while magnesium alone reached 3.75 g pot⁻ ¹ in Mg3 (47.64% RI). Combined applications generally gave the highest values, with B3Mg3 (4.60 g pot⁻ ¹; 81.10% RI) and B3Mg2 (4.36 g pot⁻ ¹; 71.65% RI) being the most productive, as shown in Fig. 4. Fertigation provided a steady nutrient supply to the root zone, sustaining chlorophyll synthesis, photosynthesis, and metabolic activity over time (Brown *et al.*, 2002). Although some fertigation treatments showed slightly lower RI% compared with foliar feeding at this stage, the method ensures continuous nutrient availability, which is critical in sandy loam soils prone to leaching (FAO, 2017).

Both foliar and fertigation methods significantly enhanced DMY at 45 days, with foliar application generally producing higher early-stage gains, particularly in high B and Mg combinations. This is likely due to the immediate uptake and utilization of nutrients via the leaves, which accelerates biomass formation during vegetative growth. Fertigation, while slower in short-term response, ensures sustained nutrient supply, which may prove more advantageous in maintaining growth in later stages.

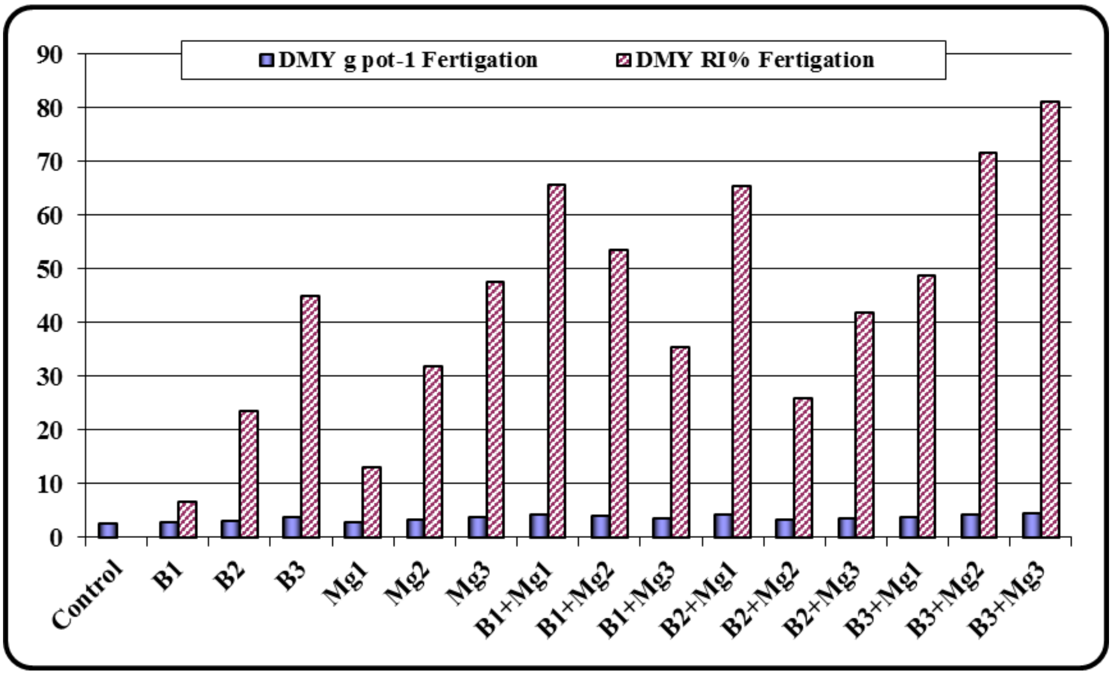

Figure 4: Effect of fertigation treatments of B and Mg on DMY of faba bean plants (g pot $^{-1}$) at 45 days of growth and its RI (%)

Macro nutrients content (N, P, K)

The data presented in Table 4 demonstrate that both boron and magnesium application, either individually or in combination, exerted a substantial effect on the macronutrient status of faba bean plants at 45 days. Across all treatments, clear improvements in nutrient concentration, uptake, and RI were observed compared with the untreated control, reflecting the responsiveness of faba bean grown in sandy soil to supplemental B and Mg nutrition. A consistent pattern was that combined applications of B and Mg were always superior to single applications, regardless of whether nutrients were supplied as foliar sprays or via fertigation.

Table (4): N , P & K concentrations ,uptake & relative increase "RI'' of faba bean plants at 45 days affected by B and Mg application.

Treatments	Application Methed																	
	Foliar									Fertigation								
	N			P			K			N			P			K		
	Con. %	Uptake mg pot^{-1}	RI %	Con. %	Uptake mg pot^{-1}	RI %	Con. %	Uptake mgpot^{-1}	RI %	Con. %	Uptake mg pot^{-1}	RI %	Con. %	Uptake mg pot^{-1}	RI %	Con. %	Uptake mg pot^{-1}	RI %
Control	1.60	40.64	0.00	0.50	12.70	0.00	0.76	19.30	0.00	1.65	41.91	0.00	0.54	13.72	0.00	0.79	20.07	0.00
B1	1.85	51.43	26.55	0.52	14.46	13.86	0.78	21.68	12.33	1.93	52.30	24.79	0.55	14.91	8.67	0.82	22.22	10.71
B2	2.14	63.77	56.91	0.55	16.39	29.06	0.80	23.84	23.52	2.19	68.77	64.09	0.58	18.21	32.73	0.84	26.38	31.44
B3	2.16	69.12	70.08	0.56	17.92	41.10	0.85	27.20	40.93	2.41	88.69	111.62	0.63	23.18	68.95	0.88	32.38	61.34
Mg1	2.03	57.86	42.37	0.53	15.11	18.98	0.79	22.52	16.68	2.14	61.42	46.55	0.61	17.51	27.62	0.83	23.82	18.68
Mg2	2.10	62.79	54.50	0.53	15.85	24.80	0.83	24.82	28.60	2.25	75.38	79.86	0.62	20.77	51.38	0.85	28.48	41.90
Mg3	2.20	69.96	72.15	0.60	19.08	50.24	0.85	27.03	40.05	2.44	91.50	118.32	0.66	24.75	80.39	0.90	33.75	68.16
B1Mg1	2.32	77.02	89.52	0.63	20.92	64.72	0.90	29.88	54.82	2.67	112.41	168.22	0.66	27.79	102.55	0.91	38.31	90.88
B1Mg2	2.41	85.80	111.12	0.65	23.14	82.20	0.96	34.18	77.10	2.60	101.4	141.95	0.68	26.52	93.29	1.07	41.73	107.92
B1Mg3	2.60	108.16	166.14	0.69	28.70	125.98	1.10	45.76	137.10	2.30	79.12	88.79	0.70	24.08	75.51	1.20	41.28	105.68
B2Mg1	2.38	81.40	100.30	0.66	22.57	77.72	0.93	31.81	64.82	2.64	110.88	164.57	0.69	28.98	111.22	0.96	40.32	100.90
B2Mg2	2.50	97.75	140.53	0.67	26.2	106.30	0.98	38.32	98.55	2.22	71.04	69.51	0.70	22.40	63.27	1.10	35.2	75.39
B2Mg3	2.63	121.51	198.99	0.75	34.65	172.83	1.13	52.21	170.52	2.37	85.32	103.58	0.78	28.08	104.66	1.22	43.92	118.83
B3Mg1	2.57	107.43	164.35	0.69	28.84	127.09	1.03	43.05	123.06	2.50	94.50	125.48	0.75	28.35	106.63	1.15	43.47	116.59
B3Mg2	2.66	124.49	206.32	0.75	35.10	176.38	1.19	55.69	188.55	2.80	122.08	191.29	0.85	37.06	170.12	1.27	55.37	175.88
B3Mg3	2.72	143.07	252.04	0.80	42.08	231.34	1.25	65.75	240.67	2.85	131.10	212.81	0.88	40.48	195.04	1.32	60.72	202.54

When comparing the two application methods, foliar application produced the highest values of nutrient uptake, while fertigation provided more uniform and sustainable responses across treatments. For instance, the maximum N uptake was recorded under foliar application (143.07 mg pot^{-1}), slightly higher than that obtained with fertigation (131.10 mg pot^{-1}) in the B3Mg3 treatment as shown in Fig. 5. Similarly, relative increases in P and K uptake were greater under foliar application (231.34 % and 240.67 %, respectively) compared with fertigation (195.04 % and 202.54 %) shown in Fig 6 and 7. Despite these higher values under foliar application, fertigation offered greater agronomic efficiency by ensuring continuous nutrient availability within the root zone, which is particularly advantageous in sandy soils characterized by rapid leaching and low organic matter (El-Metwally, 2012; Barbosa *et al.*, 2019; Liu *et al.*, 2023). By delivering nutrients directly in soluble form to the rhizosphere, fertigation promoted stable uptake and enhanced long-term efficiency. Among the three macronutrients studied, nitrogen exhibited the strongest response to B and Mg treatments, followed by potassium, whereas phosphorus showed relatively lower increases, though still significant. This ranking reflects the inherently high N demand of legumes during early vegetative growth (Marschner, 2012), the mobility and functional importance of K in osmotic regulation and assimilate transport (Mengel & Kirkby, 2001), and the relatively lower P demand at this stage compared with reproductive growth. Nevertheless, the marked improvements in P uptake under combined B and Mg treatments suggest that these elements may indirectly enhance phosphorus metabolism and root absorption capacity (Shireen *et al.,* 2018).

Overall, the results from Table 4 clearly demonstrate that the nutritional status of faba bean in sandy soils is significantly improved by the integrated application of B and Mg. These outcomes agree with earlier findings in legumes, where balanced micronutrient management improved biomass production, nutrient-use efficiency, and symbiotic performance. They also provide practical evidence that in sandy soils with inherently low fertility, combining B and Mg fertilization strategies can effectively enhance N, P, and K uptake, thus supporting sustainable productivity.

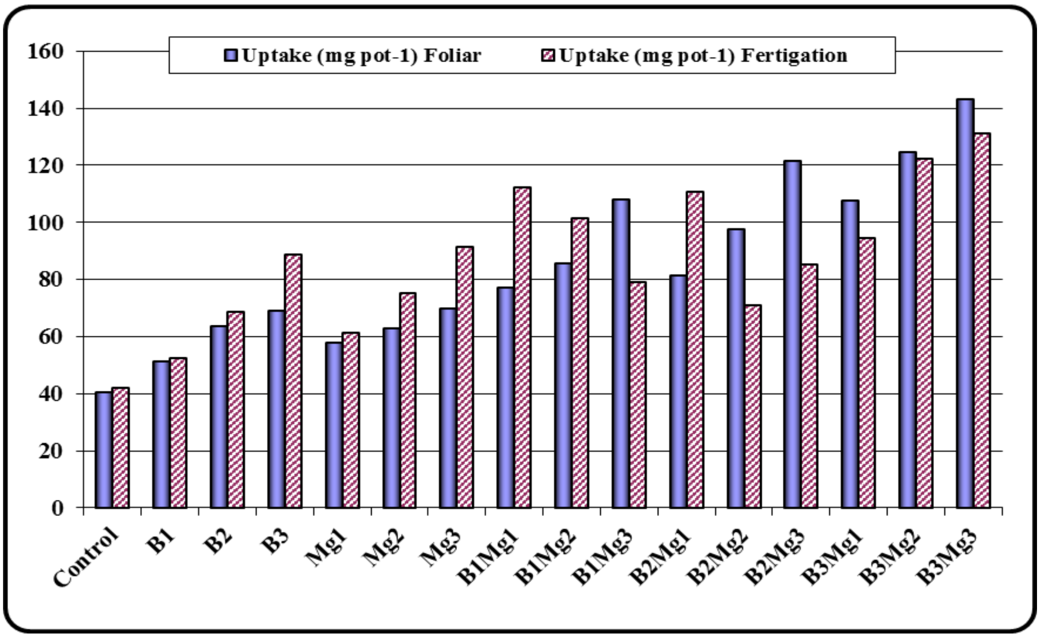

Figure 5: Effect of fertigation treatments with B and Mg on N uptake by faba bean plants (mg pot-1) at 45 days of growth.

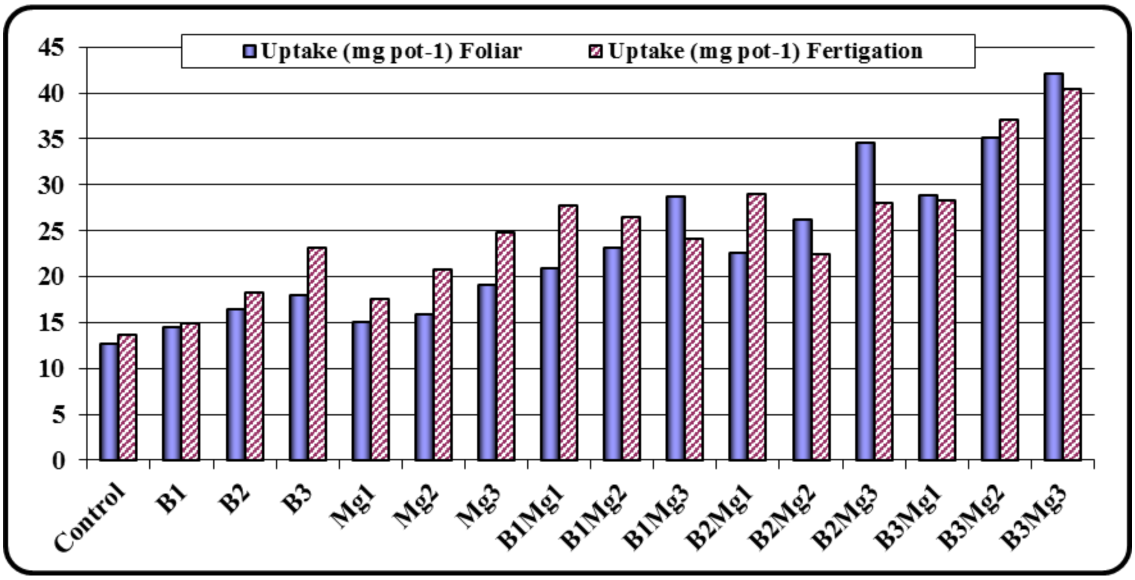

Figure 6: Effect of fertigation treatments of B and Mg on P uptake of faba bean plants (mg pot $^{-1}$) at 45 days of growth.

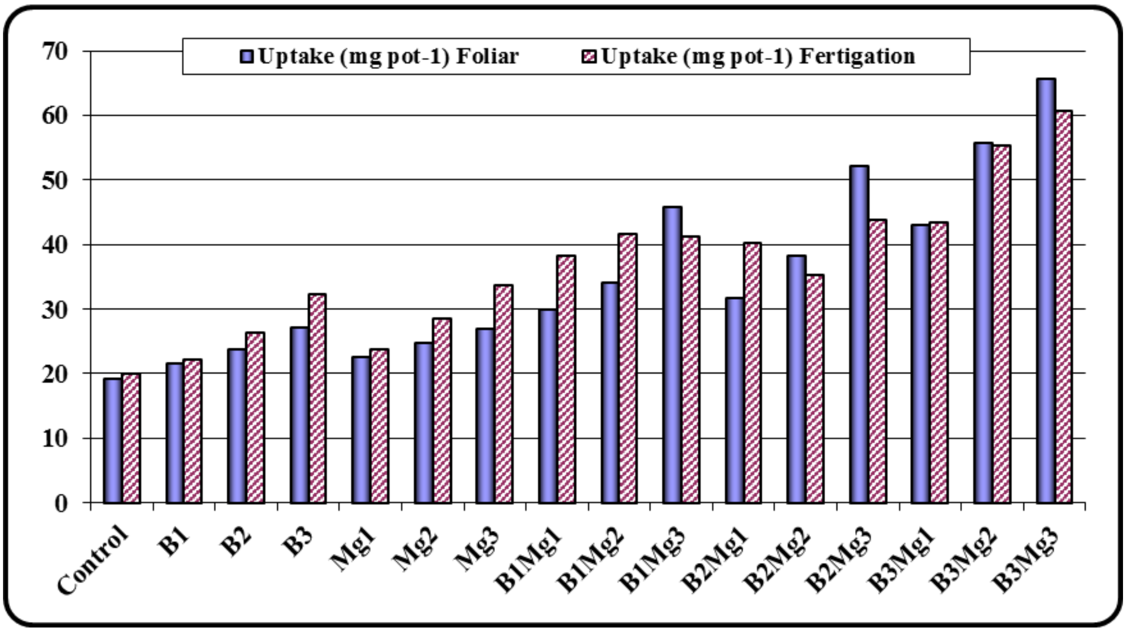

Figure 7: Effect of foliar and fertigation treatments of B and Mg on K uptake of faba bean plants (mg pot $^{-1}$) at 45 days of growth.

Effect of foliar application on N content

The response of faba bean plants to foliar-applied B and Mg was clear in terms of nitrogen concentration and uptake at 45 days. The untreated control contained 1.60% N with an uptake of 40.64 mg pot^{-1}, indicating the inherently low fertility of the sandy soil used in this study. Foliar addition of B enhanced N uptake gradually with increasing concentrations, reaching 69.12 mg pot^{-1} at the highest level (B3), corresponding to a 70% increase over control. Magnesium sprays also improved N assimilation, particularly at Mg3, where uptake reached 69.96 mg pot^{-1} (RI = 72.15%). The most pronounced response was obtained from combined foliar feeding of B and Mg, especially B3Mg3, which more than tripled the N uptake (143.07 mg pot^{-1}; RI = 252.04%).

These findings suggest a complementary role between the two nutrients. Magnesium, as the central atom of chlorophyll, promotes photosynthetic activity and drives N assimilation into amino acids and proteins (Cakmak & Kirkby, 2008). At the same time, boron enhances root activity, nodule development, and carbohydrate transport to the rhizosphere, thereby improving biological nitrogen fixation in legumes (Bolanos *et al.,* 2004). The strong synergistic effect of B and Mg highlights the importance of balanced nutrition, where one nutrient improves the physiological use efficiency of the other.

Effect of fertigation on N uptake

When the nutrients were applied through fertigation, nitrogen uptake increased even more markedly. The control recorded only 41.91 mg pot^{-1}, whereas B٣ and Mg3 resulted in 88.69 mg pot^{-1} (RI = 111.62%) and 91.50 mg pot^{-1} (RI = 118.32%), respectively. The highest fertigation treatment, B3Mg3, resulted in 131.10 mg pot^{-1} (RI = 212.81%), more than the control. The stronger response of fertigation may be explained by the continuous and uniform supply of nutrients directly into the rhizosphere, which is particularly beneficial in sandy soils with low cation-exchange capacity. Fertigation also promotes deeper root exploration and avoids the limited penetration of foliar sprays into dense canopies at later growth stages (Havlin *et al.,* 2014). In legumes such as faba bean, where symbiotic N fixation is highly sensitive to nutritional status, fertigation appears to create a more stable environment for nodulation and assimilation.

Effect of foliar application on P content

Phosphorus uptake followed a similar dynamic. The control treatment recorded 12.70 mg pot^{-1}, while foliar application of B increased uptake progressively to 17.92 mg pot^{-1} under B3 (RI = 41.10%). Magnesium sprays also enhanced P status, with uptake reaching 19.08 mg pot^{-1} (RI = 50.24%) under Mg3. Combined B and Mg sprays were substantially more effective, with the highest treatment (B3Mg3) achieving 42.08 mg pot^{-1} (RI = 231.34%), more than the control. This strong response reflects the roles of both nutrients in P metabolism: boron improves cell wall integrity and facilitates phloem loading of sugars, indirectly stimulating root activity and P absorption (Shireen *et al.,* 2018), whereas magnesium is essential for ATP synthesis, allowing absorbed P to be incorporated into energy compounds and nucleic acids (Mengel & Kirkby, 2001).

Effect of fertigation on P content

Phosphorus uptake improved more strongly under fertigation. The control value was 13.72 mg pot^{-1}, whereas B3 and Mg3 resulted in 23.18 mg pot^{-1} (RI = 68.95%) and 24.75 mg pot^{-1} (RI = 80.39%), respectively. The combined B3Mg3 treatment was superior, recording 40.48 mg pot^{-1} (RI = 195.04%). The higher efficiency of fertigation in enhancing P uptake may be attributed to better nutrient distribution in the root zone and reduced fixation compared with surface-applied nutrients. In sandy soils, P is often prone to leaching and poor retention; however, fertigation supplies nutrients in frequent, smaller doses, keeping them more readily available to the roots. Moreover, the synergistic role of Mg in stimulating photosynthesis likely improved the plant’s demand and sink strength for P, thereby accelerating uptake and assimilation (El-Habbasha *et al.,* 2015).

Effect of foliar application on P uptake

Potassium uptake also increased significantly with the application of foliar B and Mg. Control plants contained 19.30 mg pot^{-1}, whereas uptake rose to 27.20 mg pot^{-1} under B3 (RI = 40.93%) and 27.03 mg pot^{-1} under Mg3 (RI = 40.05%). The combined treatment B3Mg3 produced the highest response, with 65.75 mg pot^{-1} (RI = 240.67%). These results demonstrate the strong interaction of B and Mg with K nutrition. Boron improves assimilate translocation, which enhances K loading into phloem and its redistribution within plant tissues (Römheld & Marschner, 1991). Magnesium, as a cofactor for many enzymes, contributes to ion transport processes and balances cation uptake, resulting in improved potassium utilization efficiency. The sharp increases observed under combined treatments suggest that these nutrients not only enhance K absorption but also its internal mobilization and partitioning.

Effect of fertigation on P uptake

Fertigation proved to be even more effective in enhancing K uptake. Control plants absorbed only 20.07 mg pot^{-1}, whereas fertigation with B3 and Mg3 resulted in 32.38 mg pot^{-1} (RI = 61.34%) and 33.75 mg pot^{-1} (RI = 68.16%), respectively. The maximum effect was obtained under the combined B3Mg3 treatment, which more than tripled the control uptake, reaching 60.72 mg pot^{-1} (RI = 202.54%). These findings highlight the importance of maintaining a continuous nutrient supply through fertigation in sandy soils, where rapid K leaching often limits crop availability. By maintaining higher K levels in the root zone, fertigation supports both osmotic regulation and stomatal function, leading to improved water relations and photosynthetic efficiency (Fageria *et al.*, 2008).

The consistent superiority of fertigation for K, as well as N and P, confirms that this method is more suitable than foliar spraying for sandy soils. However, foliar feeding can still provide a valuable supplement under critical growth stages.

Conclusion

The findings of this study demonstrate that boron and magnesium play a vital role in improving the growth and nutritional status of faba bean plants grown in sandy soil. Both nutrients significantly increased fresh and dry matter yields as well as N, P, and K uptake, with the combined application showing the most potent positive effects. Fertigation proved to be more effective than foliar feeding, providing a continuous supply of nutrients to the root zone and resulting in greater nutrient uptake and relative increases, especially for P and K. Among the macronutrients, nitrogen showed the most pronounced response, followed by potassium and phosphorus.

These results highlight the importance of integrated B and Mg management to overcome the inherent fertility limitations of sandy soils. Fertigation of these nutrients, complemented by targeted foliar sprays when needed, can enhance biomass production, nutrient-use efficiency, and ultimately the productivity of faba bean in Egypt’s reclaimed lands.

REFERENCES

Abdelgawad, G.; El-Sherif, M. and Khalifa, R. (2020). Magnesium dynamics in sandy soils and its impact on crop performance. Egyptian Journal of Soil Science, 60(2): 125–137.

Abdelrahman, M.; El-Moghazy, S. and Soliman, H. (2023). Enhancing faba bean productivity under sandy soils of Egypt. Legume Research, 46(7): 955–962.

Abedini, D.; Karimi, M. and Shakeri, E. (2024). Synergistic effects of magnesium and boron on nutrient uptake and biomass accumulation in legumes. Journal of Plant Nutrition, 47(5): 812–829.

Abd El-Rahman, H.; Youssef, A. and El-Shazly, A. (2018). Fertigation strategies for micronutrients under sandy soils. Annals of Agricultural Science, 63(1): 23–32.

Al-Jaloud, A.; Al-Omran, A. and Al-Hamdi, A. (2016). Foliar application of micronutrients in legumes under arid conditions. Journal of Arid Environments, 132: 18–25.

Barbosa, V.; da Silva, J. and de Souza, R. (2019). Fertigation as a strategy to improve nutrient use efficiency in vegetable crops. Agricultural Water Management, 217: 60–66.

Berger, K.C. & Truog, E. (1939). Boron determination in soils and plants. Industrial & Engineering Chemistry, Analytical Edition, 11(10): 540–545.

Black, C.A., Evans, D.D., White, J.L., Ensminger, L.E. and Clark, F.E., (1965). *Methods of soil analysis. Part I. Physical and* *mineralogical properties*. Madison, WI: American Society of Agronomy.

Blanchart, E.; Bernoux, M.; Brauman, A.; Chotte, J.L.; Sall, S. and Serpantié, G. (2005). Plant-soil interactions in tropical sandy soils. Soil Use and Management, 21(1): 22–30.

Bolaños, L.; Lukaszewski, K.; Bonilla, I. and Blevins, D. (2004). Why boron? Plant Physiology and Biochemistry, 42(11): 907–912

Bolaños, L.; Lukaszewski, K.; Bonilla, I. and Blevins, D. (2023). Boron and legume physiology: from cell wall to nodulation. Plant Physiology and Biochemistry, 198: 107–120.

Brown, P.H.; Bellaloui, N.; Wimmer, M.; Bassil, E.; Ruiz, J.; Hu, H. and Pfeffer, H. (2002). Boron in plant biology. Plant Biology, 4(2): 205–223.

Cakmak, I. and Kirkby, E.A. (2008). Role of magnesium in carbon partitioning and alleviating photooxidative damage. Physiologia Plantarum, 133(4): 692–704.

Cakmak, I. and Kirkby, E.A. (2021). Magnesium functions in crop nutrition and yield. Plant and Soil, 475: 1–17.

Chapman, H.D. and Pratt, P.F. (1961). Methods of Analysis for Soils, Plants and Water. Berkeley: University of California.

Cottenie, A.; Verloo, M.; Kiekens, L.; Velghe, G. and Camerlynck, R. (1982). Chemical analysis of plants and soils. Ghent: Laboratory of Analytical and Agrochemistry, State University Ghent.

Cordeiro, C.F.S.; Galdi, L.V.; Silva, G.R.A.; Custodio, C.C. and Echer, F.R. (2024). Boron nutrition improves peanuts yield and seed quality in a low-B sandy soil. Revista Brasileira de Ciência do Solo, 48, e0230043.

Elbana, T.A.; Gaber, H.M. and Abdelkader, A.M. (2019). Fertility constraints in sandy soils of Egypt. Egyptian Journal of Soil Science, 59(3): 201–214.

El-Fouly, M.M.; Abou El-Nour, E.A.A. and Mobarak, Z.M. (2011). Importance of foliar application of nutrients for maximizing plant performance. International Journal of Academic Research, 3(6): 55–67.

El-Habbasha, S.F.; Hozayn, M. and Khalafallah, M.A. (2015). Phosphorus and bio-fertilizers in faba bean under sandy soils. International Journal of ChemTech Research, 8(4): 1381–1389.

Elkhouly, A.; Elsheikh, O. and Ramadan, M. (2021). Characterization of sandy soils in Egypt’s reclaimed lands. Egyptian Journal of Desert Research, 71(1): 45–58.

El-Metwally, S. (2012). Fertigation of humic substances improves yield and quality of broccoli and nutrient retention in a sandy soil. Journal of Plant Nutrition and Soil Science, 175(2): 273–281.

Erdal, I. (2016). Effect of foliar iron applications at different growth stages on iron and some nutrient concentrations in strawberry cultivars. Turkish Journal of Agriculture and Forestry, 28(6): 15–22.

Fahmy, S.; Shaban, K. and Mahmoud, R. (2024). Nutrient imbalances limiting faba bean productivity in sandy soils. Legume Research, 47(2): 310–318.

Fageria, N.K.; Baligar, V.C. and Li, Y.C. (2008). The role of nutrient efficient plants in improving crop yields in the twenty-first century. Journal of Plant Nutrition, 31(7): 1121–1157. doi:10.1080/01904160802116068.

FAO. (2017). Irrigation in the Middle East Region. Rome: FAO.

FAO. (2023). FAOSTAT Statistical Database. Rome: FAO.

Farag, M.; Hassan, S. and Youssef, A. (2025). Foliar micronutrient application for legumes under semi-arid Egypt. Journal of Agricultural Sciences, 60(2): 215–229.

Gaber, H.; El-Banna, M. and El-Shenawy, M. (2024). Magnesium nutrition in legumes under sandy soils. Journal of Plant Nutrition and Soil Science, 187(1): 1–12.

Goldberg, S. (1997). Reactions of boron with soils. Plant and Soil, 193(1–2): 35–48.

Guo, W.; Nazim, H.; Liang, Z. and Yang, D. (2016). Magnesium deficiency in plants: An urgent problem. The Crop Journal, 4(2): 83–91.

Havlin, J.L.; Tisdale, S.L.; Nelson, W.L. and Beaton, J.D., 2014. *Soil fertility and* *fertilizers*. 8th ed. Upper Saddle River, NJ: Pearson.

Huang, J. and Hartemink, A.E. (2020). Soil and environmental issues in sandy soils. *Earth-Science Reviews*, 208, 103295. doi:10.1016/j.earscirev.2020.103295.

Kim, J.H. (1996). Particle-size distribution analysis. In: *Methods of Soil Analysis: Part 4 Physical Methods*. Madison: Soil Science Society of America, pp.393–409.

Liu, H.; Wang, L. and Zhou, D. (2024). Boron physiology in legumes. Frontiers in Plant Science, 15, 1228.

Liu, H.; Zhang, Y. and Chen, W. (2023). Nutrient dynamics and management strategies in coarse-textured soils: a review. Soil & Tillage Research, 230, 105720.

Liu, J.; Shi, X. and Zhao, J. (2023). Nutrient leaching and fertility management in sandy soils. Soil and Tillage Research, 225, 105534.

Marschner, H. (2012). Marschner's Mineral Nutrition of Higher Plants. 3rd ed. Academic Press.

Mengel, K. and Kirkby, E.A. (2001). Principles of Plant Nutrition. 5th ed. Dordrecht: Kluwer.

Mínguez, M. and Rubiales, D. (2021). Faba bean agronomy and global importance. Agronomy, 11(2): 234.

Mohamed, H. and Hegab, S. (2023). Foliar feeding strategies for legumes under arid soils. Egyptian Journal of Agronomy, 45(3): 317–329.

Olsen, S.R.; Cole, C.V.; Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular 939. Washington, DC: U.S. Government Printing Office.

Page, A.L.; Miller, R.H. and Keeney, D.R. (eds.), (1982). Methods of soil analysis. Part II: Chemical and microbiological properties. 2nd ed. Agronomy Monograph No. 9. Madison, WI: American Society of Agronomy (ASA) and Soil Science Society of America (SSSA).

Peng, Y.; Li, J. and He, X. (2018). Magnesium nutrition improves nodulation and N fixation in legumes. Plant and Soil, 428(1–2): 95–108.

Römheld, V. and Marschner, H. (1991). Functions of micronutrients in plants. In: Mortvedt, J.J. (ed.) Micronutrients in Agriculture. 2nd ed. SSSA, pp.297–328.

Shaban, K.; Fahmy, S. and Mahfouz, H. (2023). Boron and magnesium deficiency in sandy soils of Egypt. Soil Use and Management, 39(2): 210–220.

Shalaby, A.; Abdelrahman, H. and El-Sayed, S. (2016). Fertigation management in sandy soils. Journal of Soil Science and Agriculture Engineering, 7(3): 173–181.

Shireen, F.; Nawaz, M.A.; Chen, C.; Zhang, Q.; Zheng, Z.; Sohail, H.; Sun, J.; Cao, H. and Huang, Y. (2018). Boron functions and availability in plants. International Journal of Molecular Sciences, 19(7): 1856. https://doi.org/10.3390/ijms19071856.

Shorrocks, V.M. (1997). The occurrence and correction of boron deficiency. Plant and Soil, 193(1–2): 121–148.

Snedecor, G.W. and Cochran, W.G. (1980). Statistical Methods. 7th ed. Ames: Iowa State University Press.

Wimmer, M.A. and Eichert, T. (2019). Mechanisms of foliar nutrient uptake. Plant and Soil, 434(1–2): 1–21.

Youssef, M. and Siam, H. (2018). Boron dynamics in calcareous sandy soils. Egyptian Journal of Soil Science, 58(4): 345–356.

إستجابة إنتاجية الكتلة الحيوية وامتصاص المغذيات الكبري في نبات الفول البلدي(*Vicia faba L.*) للتسميد الورقي والري المسمد بالبورون والمغنسيوم في التربة الرملية خلال مرحلة النمو المبكر

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الملخص العربي:

أُجريت تجربة في أصص على تربة رملية طميية أخذت عيناتها من قويسنا، محافظة المنوفية، مصر، لتقييم آثار المغنيسيوم والبورون المُقدّمَين من خلال الرش الورقي والتسميد بالري على نبات الفول. اشتملت المعاملات الستة عشر على ثلاثة مستويات من المغنيسيوم (على شكل كبريتات المغنيسيوم) والبورون (على شكل حمض البوريك) مُضافة إما بصورة فردية أم مركبة بالإضافة معاملة للمقارنة. وتمت الزراعة لمدة ٤٥ يوم ثم قياس أداء النمو، والكتلة الحيوية الطازجة والجافة وامتصاص المغذيات الكبري (النيتروجين، الفسفور، البوتاسيوم) بواسطة النبات.

أظهرت النتائج أن كلاً من البورون والمغنيسيوم عزز نمو النبات وتراكم العناصر الغذائية بشكل ملحوظ مقارنةً بمعاملة الكنترول. أدت أعلي إضافة من البورون و المغنيوم الي زيادة امتصاص النيتروجين إلي ١٤٣,٠٧ مليجرام في النبات بزيادة نسبية وصلت إلي ٢٥٢,٠٤% مقارنة بالكونترول و زاد إمتصاص الفسفور إلي ٤٢,٠٨ مليجرام في النبات بزيادة نسبية ٢٣١,٣٤% وأيضا زاد إمتصاص البوتاسيوم إلي ٦٥,٧٥ مليجرام في النبات بزيادة نسبية ٢٤٠,٦٧% وأدي اضافة العنصرين لأعلي معاملة مشتركة من خلال مياه الري لنتائج ممثالة حيث بلغ إمتصاص النيتروجين إلي ١٣١,١٠ مليجرام في النبات بزيادة نسبية وصلت إلي ٢١٢,٨١ % كذلك زاد إمتصاص الفسفور إلي ٤٠,٤٨ مليجرام في النبات بزيادة نسبية ١٩٥,٠٤% و أيضا زاد إمتصاص البوتاسيوم إلي ٦٠,٧٢ مليجرام في النبات بزيادة نسبية ٢٠٢,٥٤%، تبعت غلة المادة الطازجة و الجافة نفس الاتجاه، حيث تجاوزت الزيادات النسبية ١٠٠% في أعلى معدلات التسميد المشترك. بشكل عام، كان التسميد الورقي أكثر فعالية من الري المسمد، على الرغم من أن كلتا الطريقتين حسّنتا النمو والتغذية بشكل ملحوظ مقارنةً بالكنترول تُسلّط الدراسة الضوء على أهمية دمج أساليب التسميد الورقي والتسميد بالري لتحسين تغذية الفول البلدي المزروع في التربة الرملية المصرية بالعناصر المغذية، مما يُتيح مسارًا لتعزيز الإنتاجية وكفاءة استخدام الموارد في الأراضي المستصلحة. إنتاج الكتلة الحيوية واستجابة امتصاص الفول البلدي للمغذيات الكبرى للتسميد الورقي والتسميد بالبورون والمغنيسيوم في التربة الرملية في مرحلة النمو المبكر.