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FERTILIZATION EFFECTS ON GROWTH TRAITS AND IRON AND COPPER CONTENT OF BROAD BEAN (*VICIA FABA* L.)

W.A. AHMED[1*], A.N. ALMANSOR[2], and A.M. ALSHUMMARY[1]

[1]Department of Field Crops, College of Agriculture, University of Basrah, Basrah, Iraq
[2]Department of Machines, College of Agriculture, University of Basrah, Basrah, Iraq
*Corresponding author's email: wafa.ahmed@uobasrah.edu.iq
Email addresses of co-authors: assim.almansor@uobasrah.edu.iq, anhar.jaaz@uobasrah.edu.iq

SUMMARY

An agriculture experiment materialized during the cropping season of 2022–2023 in the Kateban Area, Basra Governorate, Iraq, to demonstrate the effect of nitrogen fertilization with three levels (0, 100, and 200 kg ha^{-1}) on two types of cultivars of broad bean plants (Shamea and local) grown in clay loam soil. The study also displayed enhance fertilization by spraying two types of liquid fertilizers (Al-Jamea Fertilizer and Communication) on the beans. Results showed the broad bean cultivar Shamea, the commercial liquid fertilizer, and the level of nitrogen fertilization (200 kg ha^{-1}) were significantly superior for plant height, plant dry weight, protein percentage, and copper content, except for the iron content. The highest values were 95.20 cm, 50.14 gm, 39.98%, and 39.98 ppm, respectively, from the interaction among the bean cultivar, type of liquid fertilizer, and the level of nitrogen fertilization at 100 kg ha^{-1}, reaching 0.5637 ppm.

Keywords: Broad bean (*Vicia faba* L.), cultivars, liquid fertilizer, protein, iron, copper

Key findings: Using the cultivar Shamea with liquid foliar fertilization increased plant growth, including plant height, dry weight of the vegetative part, protein percentage, and plant content of micronutrients (iron and copper), especially when using a nitrogen fertilization level of 200 kg ha^{-1}.

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INTRODUCTION

The bean (*Vicia faba* L.) is a chief leguminous crop used in many countries as a source of protein for humans and animals (Pötzsch *et al.,* 2018). It is essential for both agriculture and human diets globally (Etemadi *et al.*, 2018), as it provides a major source of protein and energy. Its seeds are high in protein, with estimates ranging from 25% to 40% (Natalia *et al.*, 2008), which contains massive lysine, leucine, and arginine, as three essential amino acids, and a high carbohydrate content (48%–54%), (Carmen *et al.*, 2005).

Nitrogen is usually the mineral plants need the most. It is an essential part of many proteins, amino acids, DNA, ATP, chlorophylls, and other structural components of cells. The advantages of nitrogen fertilizer for the faba bean's productivity and characteristics have attained emphasis from Abd El-Haleem *et al.,* (2019), Sherif *et al.,* (2017) and Mohamed *et al.,* (2013). Given the importance of this crop worldwide and in Iraq, and due to its low productivity in Iraq, all possible means require searching to increase the yield. Among the most important methods is cultivating high-productivity cultivars to know their response to conditions of the area to achieve the best yield in quantity and quality (Bakry *et al.,* 2011), as well as, many agriculture operations, including fertilization. One strategy for increasing crop yield and fertilizer efficiency is the proper fertilizer application (Havlin *et al.,* 2005).

One of the most crucial variables to impact nutrient availability close to the root zone is soil pH; thus, several ways exist in providing fertilizers to plants for growth and yield improvement, including direct fertilizer application to soil. When compared to soil application, foliar spraying could solve the issue of restricted nutrients' uptake from the soil. Furthermore, it is a cost-effective way to supplement nutritional components when they are unavailable from the soil, this technique might be more effective where micronutrients (iron [Fe], zinc [Zn], manganese [Mn], copper [Cu], boron [B]) adsorption is easier as soil particles when less readily available to the root system (Taiz and Zeiger, 2010).

Micro elements are necessary for the development and completion of the plant life cycle. Micronutrient deficiencies, particularly Zn, Fe, and Mn, are common in most crops due to the soil's low content of these minerals. It was evident that micronutrient spraying improved the yield (El-Masri *et al.*, 2002; Abd El-Razek *et al.*, 2012; Mekkei, 2014). In this study, growing two bean cultivars sought to determine how nitrogen fertilization and spraying with liquid fertilizer containing micronutrients affected their growth, yield, and nutrient uptake.

MATERIALS AND METHODS

An agricultural experiment, conducted during the cropping season of 2022–2023 in the Kateban Area, Basra Governorate, Iraq, had location coordinates at longitude 47° 48′ 27″ and latitude 30° 41′ 38″. The research demonstrated the effect of nitrogen fertilization at three levels (0, 100, and 200 kg ha^{-1}) and displayed enhanced fertilization by spraying two types of liquid fertilizers (Al-Jamea Fertilizer and Communication) on two cultivars of broad bean plants (Shamea and local) grown in clay loam soil, with its properties shown in Table 1. Soil samples came from 0 to 30 cm surface soil, dried and sieved with a 2 mm sieve to determine the primary properties of soil and its texture using the methods by Black *et al.* (1965). Likewise, the estimation of electrical conductivity and pH of the soil and the ions and onions employed the methods by Page *et al.* (1982).

Table 1. Physical and chemical properties of the experimental soil.

Texture	Clay	Silt	Sand	PH	Aval. N	Aval. P	Aval. K	ECe	CaCO3	OM	Fe	Cu
		g kg^{-1}				mg kg^{-1}		dS m^{-1}	g kg^{-1}		mg kg^{-1}	
Clay loam	379.8	419.2	201	7.58	16.5	12.2	110.1	4.5	372	5.62	0.013	0.011

Setting up the experiment on November 20, 2022, used a randomized complete block design with three replications, sowing the seeds of beans on a 4 m furrow for each experimental unit, containing two seeds per hole on both sides of the furrow. Phosphate and potassium application during planting followed the fertilizer recommendation (Arrak *et al.*, 2017). As for nitrogen fertilizers' addition, the study followed the levels earlier indicated. Spraying of liquid fertilizers (Al-Jamea Fertilizer and Communication at 5% concentration) proceeded on plants every 15 days after germination. At the end of the experiment, measuring the height of the plants and their dry weight continued in each experimental unit. The digestion of plants used sulfuric acid and perchloric acid according to the method of Persons and Gresser (1979), with the percentage of protein and the total plant content of iron and copper estimated following the methods presented by Jackson (1973).

RESULTS AND DISCUSSION

The results in Figure 1 and Table 2 denote a significant difference in the height of broad bean plants according to the cultivar, as the cultivar Shamea excelled, and the average values reached 82.7 cm. The reason for this could be due to the genetic characteristics of this cultivar. As for the effect of spraying with liquid nitrogen fertilizer, the commercial cultivar was notably superior. On Al-Jamea liquid fertilizer (Figure 1, Table 2), the highest value reached 82.53 cm. An explanation is the commercial fertilizer contains growth stimuli, which contribute to increasing the number of branches at the expense of plant height. The results in Figure 1 and Table 2 show the significant differences of the fertilizer level of 200 kg ha^{-1}, and the tallest reached 87.01 cm compared with 79.91 and 72.88 cm for the treatments of 100 kg ha^{-1} and the control, respectively. This is due to the plant's response to nitrogen fertilization (Alhayani, 2013, Arrak *et al.*, 2017).

Results in Table 3 show the plant height according to the crop cultivar, the type of liquid fertilizer, and the level of nitrogen fertilization, with a non-significant increase (Table 2). The highest values reached 95.20 cm for the treatment of the cultivar Shamea, a commercial liquid fertilizer, and the level of nitrogen fertilization at 200 kg ha^{-1}. Meanwhile, the lowest value (69.73 cm) came from the treatment with the local cultivar, Al-Jamea liquid fertilizer, and control.

The results in Figure 2 and Table 2 show significant differences emerged in the average dry weight of broad bean plants, which was based on the cultivar. The values reached 37.75 and 35.20 g for the cultivars Shamea and local, respectively. As for the

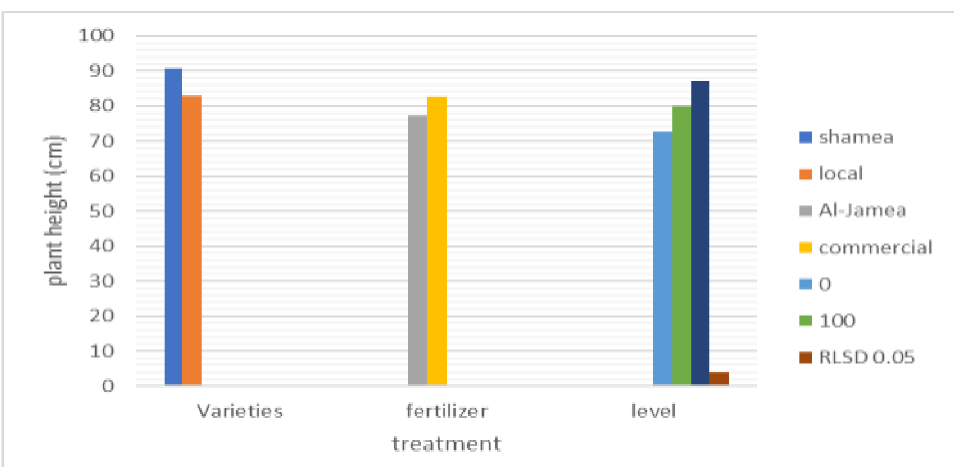

Figure 1. Effect of cultivars, liquid, and nitrogen fertilizer levels on the plant height in beans.

Table 2. Analysis of variance for various traits in beans.

Source of variation	d.f.	Cu	Fe	% protein	Dry weight	Plant height
Cultivars	1	7175.1*	2740.9*	1030.1*	160.5*	262.4*
Liquid fertilizers	1	1047.4*	395.6*	207.7*	1081.8*	192.7*
Fertilizer levels	2	4483.8*	825.7*	1446.6*	5217.2*	474.4*
Interaction (V x L x F)	2	177.5*	53.3*	2.9 ns	217.2*	1.8 ns

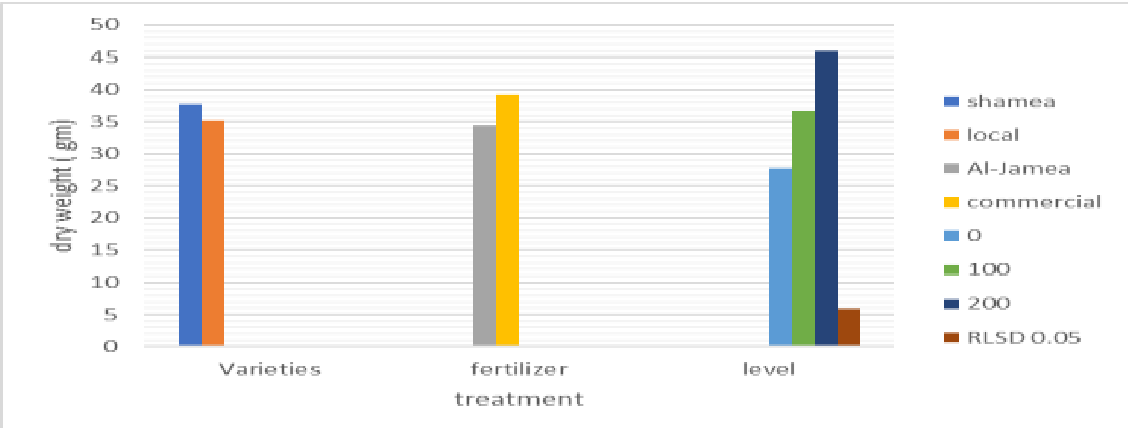

Figure 2. Effect of cultivars, liquid, and nitrogen fertilizer levels on the dry weight in beans.

addition of liquid fertilizers, the results in Figure 2 and Table 2 implied the commercial fertilizer was considerably different from Al Jamea fertilizer, reaching the topmost value of the bean plant's average dry weight at 39.23 g. The reason for this is the ability of the plant to respond to spraying and increase growth (Arrak *et al.,* 2017). The results in Figure 2 and Table 2 indicated substantial variations in the level of nitrogen fertilizer (200 kg ha^{-1}) on the dry weight of broad bean plants. The value reached 46.62 compared with 36.72 and 27.73 for the treatments of 100 kg ha^{-1} and the control, respectively. This is due to the improvement in plant growth and increase in height (Figure 1), as reflected in the dry weight of the plant. This is consistent with the results by Fouda *et al*. (2017), who found fertilization led to an increase in dry matter in the bean plant.

Results in Tables 2 and 3 revealed the treatment of cultivar Shamea with commercial liquid fertilizer and the nitrogen fertilization level of 200 kg ha^{-1} increased the average dry weight of the plant, as the value reached 50.14 g. Meanwhile, the treatment of the local cultivar with the Al-Jamea liquid fertilizer, and the control treatment had the lowest value of dry weight per plant (25.23 g). The reason for this may be due to the poor growth of the local cultivar (Figure 2) despite the addition of both types of fertilization treatments.

The results in Figure 3 and Table 2 detailed significant differences in the percentage of protein in the bean plant at the end of the experiment, as the cultivar Shamea outperformed and reached 29.35% compared with 23.28% for the local cultivar. This is due to the genetic characteristics of the cultivar and its ability to adapt and grow in Iraqi soils. As for the results in Figure 3 and Table 2, it was evident that remarkable distinctions appeared in the percentage of protein in the bean plant when sprayed with the liquid fertilizer. The commercial fertilizer was superior to the local fertilizer, with values of 27.84% and 24.80%, respectively. Figure 3 and Table 2 provided prominent alterations in the level of nitrogen fertilization, and the highest value reached 32.19% at the level of

Table 3. Effect of interaction between factors on plant height, dry weight, and protein percentage in beans.

Liquid fertilizer	Cultivars	Plant height (cm)		
		0	100	200
Commercial	Shamea	79.67	85.77	95.2
Al-Jamea		70.67	80.49	85.85
Commercial	Local	71.32	77.02	86.21
Al-Jamea		69.73	76.35	80.77
Liquid fertilizer	Cultivars	Dry weight (g)		
		0	100	200
Commercial	Shamea	30.46	38.78	50.14
Al-Jamea		28.14	36.97	45.5
Commercial	Local	27.1	37.35	47.54
Al-Jamea		25.23	33.78	37.78
Liquid fertilizer	Cultivars	Protein (%)		
		0	100	200
Commercial	Shamea	24.13	29.97	39.98
Al-Jamea		19.97	28.02	34.07
Commercial	Local	18.17	26.31	28.5
Al-Jamea		16.09	24.42	26.22

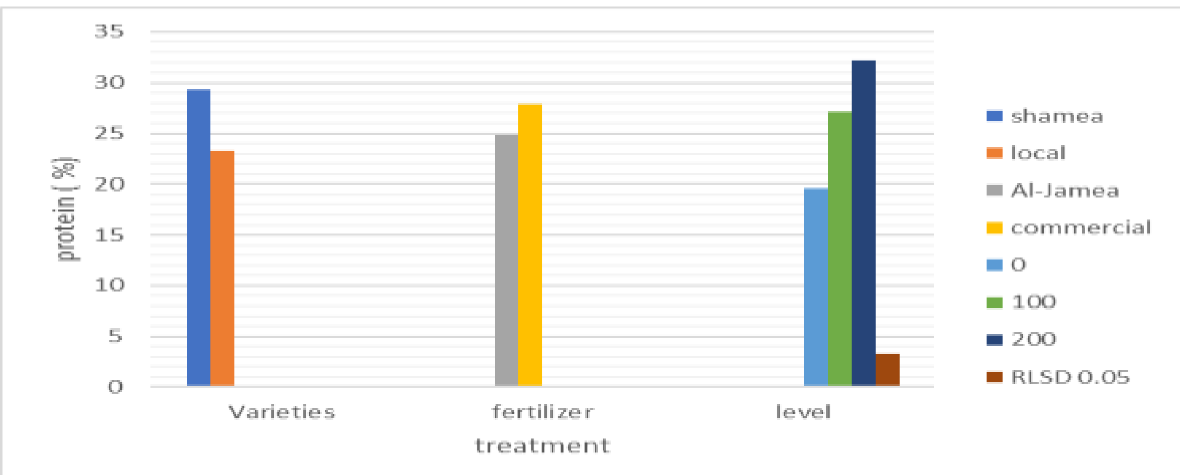

Figure 3. Effect of cultivars, liquid, and nitrogen fertilizer levels on the protein content in beans.

200 kg ha^{-1}. The reason for this could be the plant's response to nitrogen fertilization and its ability to synthesize protein (Abd Alqader *et al.*, 2020).

The findings in Table 3 show the effect of the triple interaction of the crop cultivar, the type of liquid fertilizer, and the level of nitrogen fertilization on the percentage of protein in the plant. No significant differences emerged (Table 2) between the treatments; although, a slight increase occurred in the percentage of protein, with the maximum value reaching 39.98% for cultivar Shamea, with commercial liquid fertilizer and the level of nitrogen fertilization at 200 kg ha^{-}1. Conversely, the lowest values were 16.09% for the treatment of a local cultivar, Al-Jamea liquid fertilizer, and the control treatment.

Outcomes shown in Figure 4 and Table 2 implied significant differences in the rate of iron content in the bean plant. The cultivar Shamea achieved the topmost value compared with the local cultivar, and the values were 0.3862 and 0.1439 ppm, respectively. When

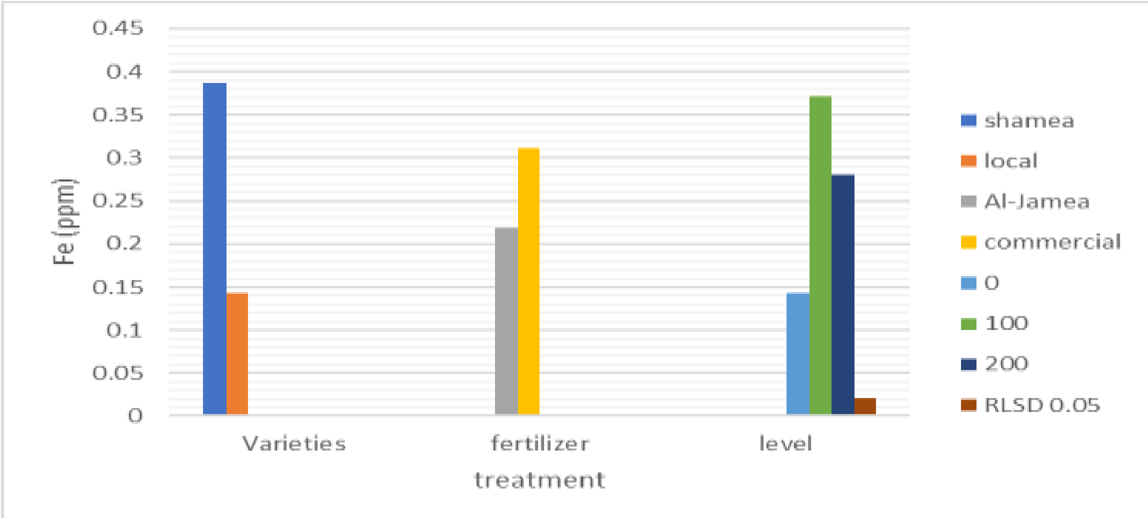

Figure 4. Effect of cultivars, liquid, and nitrogen fertilizer levels on the Fe content in beans.

Table 4. Effect of interaction between factors on the Fe and Cu content in beans.

Liquid fertilizer	Cultivars	Fe content		
		0	100	200
Commercial	Shamea	0.2514	0.5637	0.5131
Al-Jamea		0.1592	0.5201	0.3101
Commercial	Local	0.1452	0.231	0.162
Al-Jamea		0.0167	0.1728	0.1354
Liquid fertilizer	Cultivars	Cu content		
		0	100	200
Commercial	Shamea	0.2709	0.5713	0.7085
Al-Jamea		0.2397	0.3108	0.6596
Commercial	Local	0.2206	0.2633	0.3464
Al-Jamea		0.1862	0.2018	0.314

spraying liquid fertilizers, the results available in Figure 4 and Table 2 signify prominent variances between the commercial liquid fertilizer compared with the factory fertilizer of the university in the average iron content of the bean plant. The values were 0.3111 and 0.2190 ppm, respectively. The outcomes in Figure 4 and Table 2 exhibit considerable differences in the rate of iron content in the bean plant with the variation in the level of nitrogen fertilizer added. The highest values reached 0.3719 ppm at the level of fertilization of 100 kg ha^{-1} for iron absorption and utilization. This agrees with what Ahmed (2007) found. An inverse relationship existed between the iron content in the plant and the nitrogen fertilization, as it led to a decrease in the absorption of iron and a decrease in its content in the plant.

Results in Tables 4 and 2 showed there are noticeable differences in the plant content of iron according to the diverse treatments of the experiment (crop cultivar, type of liquid fertilizer, and level of nitrogen fertilization). The cultivar Shamea and the type of commercial fertilizer at the level of nitrogen fertilization (100 kg ha^{-1}) reached 0.5637 ppm, while the lowest value was 0.1354 ppm for the treatment of a local cultivar, Al-Jamea liquid fertilizer, and the control.

Figure 5 and Table 2 show study findings on the superiority of the cultivar Shamea over the local cultivar in the copper content of broad bean plants, with values of 0.4601 and 0.2554

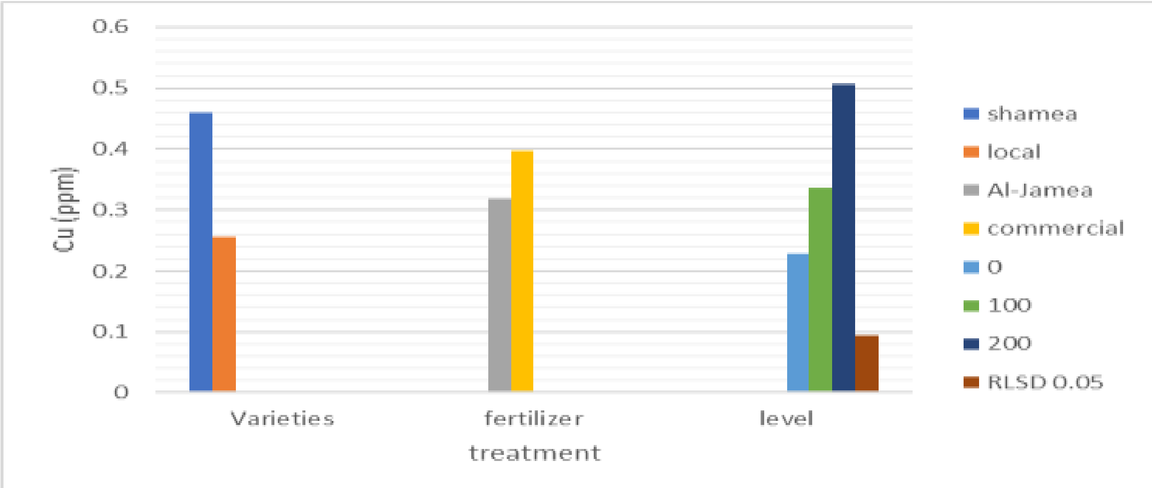

Figure 5. Effect of cultivars, liquid, and nitrogen fertilizer levels on Cu content in beans.

ppm, respectively. As for the application of liquid fertilizer spraying, the results (Figure 5 and Table 2) show the commercial fertilizer spraying was significantly superior to the Al-Jamea liquid fertilizer, having the values of 0.3968 and 0.3187 ppm, respectively. The reason could be spraying the plants increased the plant's ability to absorb copper from the soil. Moreover, the outcomes in Figure 5 and Table 2 detailed remarkable modifications in the rate of copper content in the bean plant with the addition of nitrogen fertilizer. The level exceeded at 200 kg ha^{-1}, and the value reached 0.5071 ppm compared with 0.3368 and 0.2293 ppm for the treatment of 100 kg ha^{-1} and the control, respectively.

The reason could be the increase in vegetative growth (Figure 2), which encouraged the uptake of copper from the soil. This is analogous to the study of Ahmed and Saleh (2016). They found a direct relationship between the copper content in the plant and the nitrogen fertilization existed, as it led to an increase in the absorption of copper and an increase in its content in the plant (Al-Zubaidi, 2024; Merhij *et al*., 2024; Sarhan *et al*., 2024). Results in Table 4 showed the cultivar Shamea and the commercial fertilizer at the level of nitrogen fertilization of 200 kg ha^{-1} significantly increased the rate of the copper content in the plant (0.7085 ppm). However, for the local cultivar, Al-Jamea liquid fertilizer, and the control treatment, the lowest value appeared (0.3140 ppm).

CONCLUSIONS

The cultivar Shamea outperformed the local cultivar and the commercial liquid fertilizer over the university-manufactured fertilizer in all the studied characteristics (plant height, dry weight, percentage of protein, and the plant's content of the elements iron and copper). The concentration of 200 kg ha^{-1} of nitrogen also outperformed in all the studied characteristics, except the plant's content of iron element. The highest values were 95.20 cm, 50.14 g, 39.98%, and 39.98 ppm for plant height, dry weight, protein percentage, and copper content, respectively. For the interaction among the bean cultivar, the type of liquid fertilizer, and the level of nitrogen fertilization (100 kg ha^{-1}), it reached 0.5637 ppm.

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