



Effect of Some Macronutrients Foliar Application on The Quantitative and Qualitative Traits of Fenugreek (*Trigonellafoenum-graecum L.*)

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Abstract: This study was conducted in the experimental field of Agronomy Department, Faculty of Agriculture, Urmia University in 2017. The purpose of this study was, to examine the effect of foliar application of 3 levels macro nutrients (nitrogen, phosphorus, potassium) in different 3 levels dosage of these elements (2, 3 and 4g/1000) on yield and yield components of Fenugreek herb. Results showed that foliar application of macro nutrients was significant in plant height, number of pod, number of seeds per pod, pod length, 1000 grain weight, seed yield and biomass, seed nitrogen and protein percentage of Fenugreek. The highest grain yield (1029.2 kg/ha) and seed protein percentage (12.4%) were obtained in the nitrogen treatment. Also the lowest 1000-seed weight was achieved in control. The dosage of macro nutrients (excluding number of seeds per pod and seed yield) had a significant effect on the observed traits. The highest biomass yield (1574.17 kg/ha) was gained through 4g/1000, however the highest seed protein percentage (11.26%) was observed by 2g/1000. Therefore, foliar application method reduces utilization of chemical fertilizers, which can increase the efficiency of fertilizer application and decrease fertilizer nutrient losses.

Keywords: Plant nutrition, pharmaceutical plants, macro elements, seed yield

Yapraktan Makro Besin Element Uygulamalarının, Boyotu (*Trigonellafoenum-graecum L.*) Bitkisinin Verim ve Kalite Özellikleri Üzerine Etkisi

Öz: Bu çalışma Urmia Üniversitesi, Ziraat Fakültesi, Tarla Bitkileri Bölümü deneme tarlasında 2017 yılında yürütülmüştür. Araştırmanın amacı, yapraktan 3 farklı makrobesin elementlerin (Azot, fosfor, potasyum), farklı 3 dozdaki (2, 3 and 4 g/1000) uygulamaların, boyotu bitkisinin verim ve verim özellikleri üzerine etkilerinin incelenmesidir. Araştırma sonuçlarına göre boyotu yapraklarına uygulanan makro besin elementlerin, bitki boyu, bakla sayısı, bakladaki tane sayısı, bakla uzunluğu, bin tane ağırlığı, tane ve biyomas verimi, tanedeki nitrojen ve protein oranına etkisi anlamlı bulunmuştur. En yüksek tane verimi (1029.2 kg/ha) ve protein oranı (12.4%), azot uygulamasından elde edilmiştir. Ayrıca en düşük bin tane ağırlığı kontrolde saptanmıştır. Farklı dozdaki makrobesin elementlerin etkisi incelenen tüm özelliklere (bakladaki tane sayısı ve tane verimi haric) anlamlı etkisi bulunmuştur. En yüksek biyomas verimi (1574.17 kg/ha), 4g/1000 ve en yüksek tanede protein oranı (11.26%), 2g/1000 uygulamalarından elde edilmiştir. Sonuç olarak, yaprak uygulama yöntemi, kimyasal gübre kullanımı azaltıp, böylece gübre uygulamalarının etkisini artırıp ve gübre besin kaybını azaltabilmektedir

Anahtar Kelimeler: Bitki besleme, ilaç bitkileri, makro elementler, tane verimi

1. Introduction

Recently, there has been renewed interest in cultivation of medicinal and aromatic plants which

have long been of particular importance in different parts of the world. These systems have played an important role in creating diversity and sustainability (Ghiyasi et al., 2015). One of these

herbs is fenugreek. *Trigonella foenum-graecum* L., an angiosperm or flowering plant, is an annual plant in the family Fabaceae as dicots with separated petals and leaves consisting of three small obovate to oblong leaflets. Fenugreek is an annual herb whose height reaches 50 centimeters. Fenugreek seeds, as the most important part of the herb, have a lot of uses (Bhunja et al., 2017). Saponins, mucilaginous compounds (28%), alkaloids and oils containing unsaturated acids (6-10%) constitute the pharmaceutical ingredients of fenugreek seeds. Fenugreek is one of the medicinal plants that has long been used in traditional medicine of Iran and different nations and has been shown to have significant therapeutic benefits. Fenugreek has a wide range of therapeutic effects, such as, anti-inflammatory, reduce blood sugar levels in diabetics, anti-spasmodic, anticancer, reduce cholesterol, triglyceride hypertension and promote digestion (Bahmani et al., 2016). The successful production of plants requires proper soil and adequate quantities of nutrients. Hence, the soil provides the vast majority of plant nutrients. Aside from carbon, oxygen and hydrogen, which are mainly supplied by the air and water, the main source of the nutrients required by plants is the soil solution. In the soil, there are almost all the elements of in the periodic table, and regardless of their beneficial or hurtful nature, plant absorbs them. Elements should be in the form of compounds that are accessible for plants, and also the balance between their amounts is imperative (Ghiyasi et al., 2015). Elements should be in the form of compounds that are easily absorbed by plants. Accordingly, the balance between nutrient amounts is also vital. Therefore, the nutrients in the soil play an important role in determining the growth and yield of the plant and improving the quality of the product. Along these lines, nitrogen is the most important element of soil fertility and forms the main part of soil fertilizer application. Phosphorus, after nitrogen, is the most widely used elements for the plant. This element is involved in all processes of energy transfer and signal transduction (Ferrante et al., 2017).

Increasing the quantitative and qualitative performance of medicinal plants is of particular importance due to the increasing population and demand of pharmaceutical industries for raw materials. One approach to increase yield is to increase dry matter production per unit area through employing chemical fertilizers (Moore et al., 2017). Several lines of evidence indicated that, the excessive use of chemical fertilizers in agricultural systems is often accompanied by problems such as nitrate leaching and groundwater contamination. Therefore, the appropriate use of various fertilizers is the most important approach for maintaining and improving soil fertility and increasing the yield of agricultural products (Kataki et al., 2016).

A number of studies have identified that the scientific application of chemical fertilizers to achieve optimal conditions for the utilization of soil and water resources depends on the full recognition of soil fertility, the determination of the plant's requirement for fertilizer elements under different climatic and cultivation conditions, and attempts to integrate and modify growth factors in order to have Optimized yields continuously (Shiva, 2016). In proper plant nutrition, not only must each element be sufficiently available to the plant, but, the ratio and balance of the elements are also important, because in the conditions of inappropriate nutrition, adding a number of nutrients, not only does not increase plant performance, but also cause disorders in plant growth and ultimately loses the product. (Fageria, 2016).

Therefore, feeding the leaf or foliar application of nutrients is one of the methods to reduce the use of chemical fertilizers, which, increases the efficiency of fertilizer application (Liu and Lal, 2015). All of the studies reviewed here support the notion that, foliar application method, in addition to preserving economic aspects, rapid impact and environmental protection, retains the physical structure of the soil and prevents soil nutrient imbalances that are very useful for achieving sustainable agricultural goals. Thus, the objective

of this study was to determine the effect of foliar application of some macronutrients in different doses on the quantitative and qualitative traits of fenugreek.

2. Material and Method

This research was carried out as a factorial experiment in a randomized complete block design (RCBD) with 12 treatments and 3 replications in the spring of 2017 at the research farm of the Faculty of Agriculture, Urmia University (with a geographical position of 37 degrees, 31 minutes north latitude and 45 degrees and 2 minutes east longitude with 1320 meters above sea level) (Khoshbakht, 2006).

The first factor was spraying of microelements in 4 levels (nitrogen, phosphorus, potassium and control) and the second factor was the dose of these elements in 3 levels (2, 3 and 4 g/L). Each experimental unit was considered with 3 meters in length and 3 meters in width, and included 5 rows which the spacing between and on the rows was 50 cm and 10 cm respectively, hence, the area of each experimental plot was 9 square meters.

After preparing the plots, late planting was carried out in the first month of July. The operation and irrigation were conducted according to the plant's needs. According to the results of soil analysis, field soil type was clay loam with pH 2.7, salinity of 12.12 dS / cm and 0.13% nitrogen. The amount of phosphorus and potassium in the soil was 9.1 and 450 mg / kg. The foliar application of the elements was conducted before flowering in two stages with interval of 15 days. The nutrition solution volume used in each plot was 250 liters per hectare or 0.75 liters per experimental unit. Spraying was carried out between 18-20 pm without wind conditions.

The final harvest of Fenugreek was made in the end of September, 2016. Morphological traits and yield components were measured at physiological stage using 10 plants per plot. The plant height, number of pods per plant, number of seeds per pod, pod length, 1000 seed weight, grain yield, biological yield, grain nitrogen and protein content

were among the studied traits. Grain nitrogen content was measured by the German Vapodest 20, Kjeldahl analyzer apparatus. The protein percentage was obtained by multiplying the nitrogen content in constant coefficient of 6.25 (Parimi et al., 2015).

For the estimation of final yield in each plot, after eliminating the marginal effects, one square meter area was harvested (two middle rows), and seed yield based on 12% moisture content was computed (Data analysis was carried out using SAS 9.1 software after ensuring their normalization (SAS, 2002). Also, for mean comparison, the Duncan method was used at 5% probability level.

3. Results and Discussion

3.1. Plant height (cm)

According to the analysis of variance table, the traits showed that the application of macronutrients at 1% and also the dosage treatments at 5% probability level had a significant effect on plant height (Table 1). The results obtained from mean comparison displayed that the highest plant height was related to nitrogen application (22.71 cm) and the lowest value was gained from control (19.81 cm) (Fig. 1). It has been demonstrated that using nitrogen fertilizer significantly increases the plant height of safflower (Sampaio et al., 2016). There is a consensus among scientists that improvement of nutritional status and their positive role in photosynthesis and the performance of photosystems are effective in enhancing growth indices such as plant height and pod length.

On the other hand, the deficiency of nutrients due to the adverse effects on biosynthesis of hormones, including auxin, can reduce stem height, pod length and plant yield (Bennett et al., 2017). From the results of the mean comparison, it can be seen that, in terms of dosage treatments, the dosage of 4 g/L had the highest plant height (21.87cm) and the lowest value was dosage of 2 g/L (20.24 cm) (Fig. 2). Pavlista et al., (2016) reported that the height of canola plant increased significantly by foliar application of nutrients.

Table 1. Variance analysis of some traits of Fenugreek affected by foliar application with some macronutrients in different doses**Tablo 1.** Yapraktan uygulanan farklı dozlarda bazı makro besin elementlerin boyutu bitkisinde bazı özellikleri üzerine etkisine ait varyans analiz sonuçları

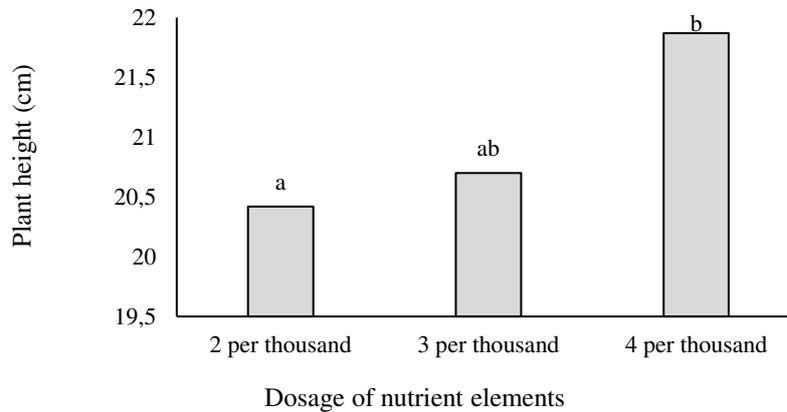
Source of variation	Df	Plant height	Number of pod	Pod length	Number of seed per pod	1000 seed weight
Replication	2	50.56	2635.52	15.30	2.22	23.55
Foliar application(F)	3	14.03**	594.84**	4.58*	1.53 ^{ns}	2.9**
Dosage (D)	2	6.68*	288.69**	5.50*	0.33 ^{ns}	19.71**
(F) × (D)	6	2.66 ^{ns}	42.39 ^{ns}	1.39 ^{ns}	1.38 ^{ns}	0.41 ^{ns}
Error	22	1.88	34.89	1.19	1.04	0.04
C.V (%)		6.52	6.18	11.91	14.7	1.21

*, ** and ns, Significant at 5% and 1% levels of probability, non-significant, respectively.

Table 2. Variance analysis of some traits of Fenugreek affected by foliar application with some macronutrients in different doses**Tablo2.** Yapraktan uygulanan farklı dozlarda bazı makro besin elementlerin, boyutu bitkisinde bazı özellikleri üzerine etkisine ait varyans analiz sonuçları

Source of variation	Df	Biological yield	Seed yield	Seed nitrogen percent	seed protein percent
Replication	2	2973.41	2300.28	0.003	0.26
Foliar application(F)	3	783.49**	773.82**	0.13**	11.19**
Dosage (D)	2	334.69**	189.77 ^{ns}	0.013**	1.13**
(F) × (D)	6	13.83 ^{ns}	66.29 ^{ns}	0.0005 ^{ns}	0.04 ^{ns}
Error	22	17.31	64.63	0.0004	0.03
C.V (%)		8.76	18.56	1.81	1.81

*, ** and ns, Significant at 5% and 1% levels of probability, non-significant, respectively.

**Figure 1.** Mean comparison of different concentrations of foliar application on Plant height of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.**Şekil 1.** Boyutu bitkisinde yapraktan uygulanan farklı element dozlarına ait bitki boyu ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan çoklu aralık Test) göstermektedir)

3.2. Number of pods per plant

It can be inferred from the analysis of variance table that the observed traits revealed the foliar application of macro elements and also the dosage treatments had a significant effect on the number of pods ($p \leq 0.01$) (Table 1). As shown in Fig. 3, the highest number of pods was found to nitrogen application (10.6), while the lowest was observed in control treatment (8.7). Meanwhile, there were

no significant differences between phosphorus and potassium treatments.

What stands out in the Fig. 4 concerning dosage treatments is, the highest number of pods were detected in the dose of 4 g/L (9.8), and the lowest dose was found in the treatment of 2 g/L (9.9), and dosage of 3 and 4 did not have significant differences. Findings of Brahim et al., (2017) indicated a significant decrease in the number of

Pods per plant due to nutrition deficiency. Zhang, (2015) pointed out that, among the yield components, number of pods per plant was the most important trait to determine the yield and had the highest correlation with grain yield. The number of pods is the most sensitive part of the yield components, which is affected by the environmental conditions and agronomic management.

3.3. Number of seeds per pod

The table 1 illustrates that, foliar application of microelements and also dosage treatments did not have a significant effect on the number of seeds per pods of fenugreek, and their interaction was not significant as well. The number of seeds per pod is the most stable part of the pulses yield, since the number of ova cells in all ovaries is the same. Therefore, the number of seeds per pod or the declining in the number of seeds does not have the same impact comparing the number of pods, on yield fluctuations. It has also been reported that the agronomic methods create small difference in the number of seeds per pod (kumari et al., 2017).

3.4. Pod length (cm)

The results of the analysis of variance are summarized in table 1. It is apparent from this table that foliar application of macro elements and also dosage treatments has a significant effect on the

length of the pod ($p \leq 0.05$). The mean comparison illustrated that the highest pod length was observed in nitrogen application (10.41 cm) and the lowest value was found in the control treatment (8.5 cm) and there was no significant difference between the control and potassium treatments (Fig. 5).

From the dosage treatments data Figure 6, it is apparent that, the highest pod length was related to 4 g/L treatment (9.93cm) and the lowest was at a dose of 2 g/L (8.66 cm). Doses of 2 and 3 g/L were placed in a same statistical group. Studies demonstrated that spraying of nutrients in rapeseed significantly increased pod length (Gutierrez-Gomboa et al., 2017). Pourmohammad et al., (2014) also reported similar results on the significance of the nutrient foliar application on pod length in rapeseed. As noted by researchers, although the length of the pod has no significant effect on the yield, cultivars with a longer pod produce more yield (Tajbakhsh and Ghiyasi, 2008). Fahad et al., (2014) conducted an experiment to investigate the effect of nutrients on wheat yield and reported that foliar application of nutrients significantly increased spike length. They interpreted that the increase in spike length accompanied with boosting demand for assimilates and the enhancing photosynthesis of the flag leaf which leads to increase the wheat yield.

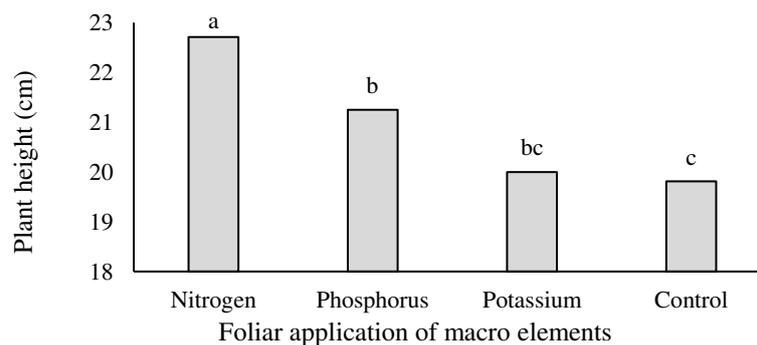


Figure 2. Mean comparison of different elements foliar application on Plant height of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 2. Boyotu bitkisinde yapraktan uygulanan farklı elementlerine ait bitki boyu ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

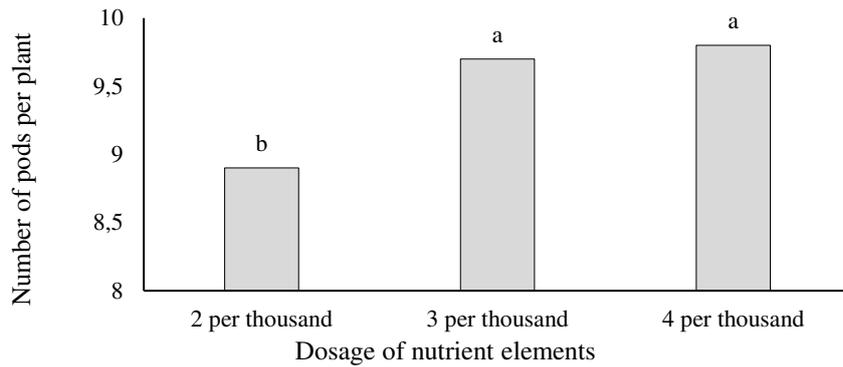


Figure 3. Mean comparison of different concentrations of foliar application on number of pods per plant of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 3. Boyotu bitkisinde yapraktan uygulanan farklı element dozlarına ait bitkide bakla sayısı ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

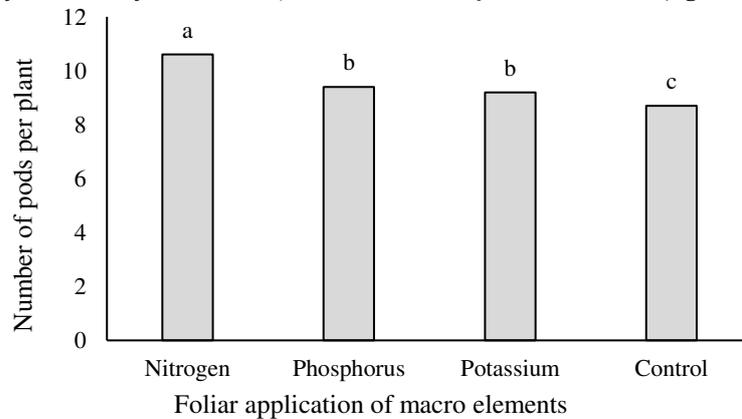


Figure 4. Mean comparison of different elements foliar application on number of pods per plant of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 4. Boyotu bitkisinde yapraktan uygulanan farklı elementlerine ait bitkide baklasayısı ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

3.5. Thousand-seed weight (g)

As shown in table1, the observed traits showed that application of macro elements as well as dosage treatments had a significant effect on 1000-seed weight ($p \leq 0.01$). The mean comparison of the studied traits indicated that nitrogen application had the highest (17.29 g) 1000 seed weight, while the lowest (15.97g) was obtained from control treatment (Fig. 7). There was not significant difference between nitrogen and phosphorus application.

The results of the dosage mean comparison were summarized in Figure 8. The highest (18.44g) 1000-grain weight was obtained at the dose of 4 g/L and the lowest (15.63g) at a dose of 2 g/L. The photosynthesis that occurs during grain filling is

usually the most important source of grain weight and yield. The reason is the most of assimilates are used before grain filling in vegetative or flowering stage, whereas during grain filling process, assimilates are often assigned to the grain (Trachsel et al., 2016). Ullah et al., (2010) reported an increase in the one thousand-seed weight of corn due to the foliar application of nitrogen fertilizers. Tsige and Abebe., (2016) reported an increase of 6 -16% in the one thousand-seed weight as a result of foliar application on wheat.

Ha et al., (2015) stated that with the optimal application of essential nutrients in rapeseed, the maximum 1000 seed weight was obtained. They identified that nitrogen for biosynthesis of growth regulators such as indoleacetic acid and

carbohydrates is crucial which results in enhancement of yield components. The enhancement could be attributed to the importance of N in the accumulation of assimilates in the grains at the end of growth stages and consequently, the production of larger and heavier seeds.

3.6. Biological yield (kg/ha)

It can be seen from the data in the table1 that macronutrient and dosage treatments had a significant effect ($p \leq 0.01$) on biological yield. The mean comparison of the studied traits specified that the highest (1574.17 kg/ha) biological yield was assigned to nitrogen treatment, and the lowest (1010.93 kg/ha) was allocated to control treatment, and control with Potassium treatment was in a same statistical group (Fig. 9). In terms of dosage treatments, it was observed that the highest (1600.6 kg/ha) biological yield was allotted to the dose of 4 g/L treatment and the lowest (989.1 kg/ha) amount was given to the dose of 2 g/L (Fig. 10). Increasing activity of sucrose synthetize and glutamine synthetize due to nitrogen fertilizer application is likely responsible for increasing metabolic activity of the plant and internodes biomass, thereby increasing biological

yield. In a report Hoste et al., (2016), the use of essential nutrients has led to a significant increase in biological yield, which was due to the better nutrition of leaf and stem and eventually increased photosynthesis. Biological yield indicates the total biomass of the plant (total dry weight), which the effective absorption of nutrients (proper nutrition) influences on its enhancement. Given the fact that nitrogen is present in the protein structure, nucleic acids, chlorophylls, enzymes and most vitamins (Keshavarz and Sanavy., 2015). With increasing nutrients in the soil, the number of physiological sinks increases for dry matter. Control treated plants had less growth and development because of a lack of nutrients (Zubair et al., 2017).Hafez et al. (2015) in a study on spinach, found that nitrogen fertilizer increased the growth and yield components due to enhancing biological nitrogen fixation (BNF), phosphate solubility and the production of hormones that effect on the absorption of nutrients and photosynthetic apparatus. In fact, increasing the absorption of water and nutrients with appropriate densities enhances the photosynthesis, which has led to the production of more assimilates and improved biological performance (Fageria et al., 2010).

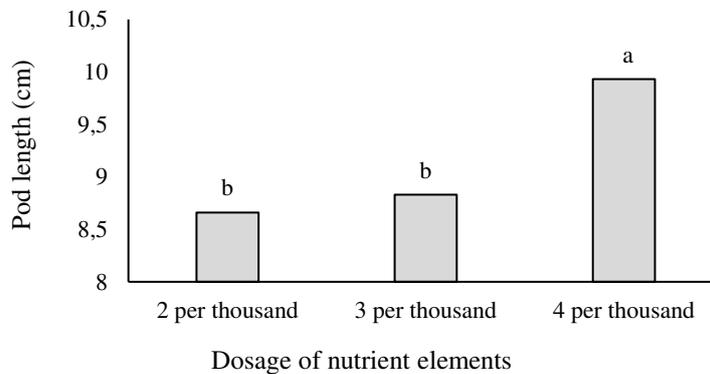


Figure 5. Mean comparison of different concentrations of foliar application on pod length of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 5. Boyutu bitkisinde yapraktan uygulanan farklı element dozlarına ait bitkide bakla uzunluğu ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

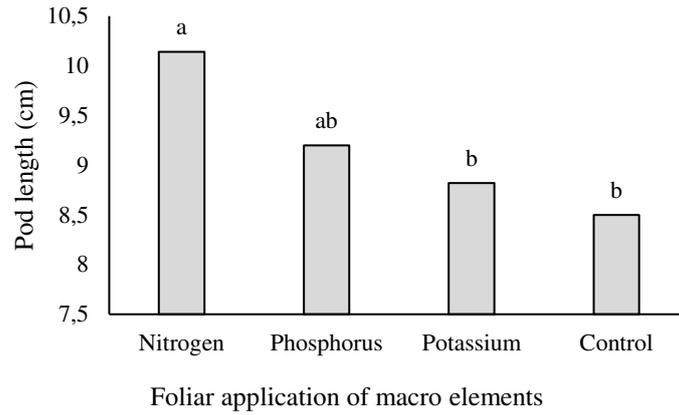


Figure 6. Mean comparison of different elements foliar application on pod length of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 6. Boyotu bitkisinde yapraktan uygulanan farklı elementlerine ait bitkide bakla uzunluğu ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

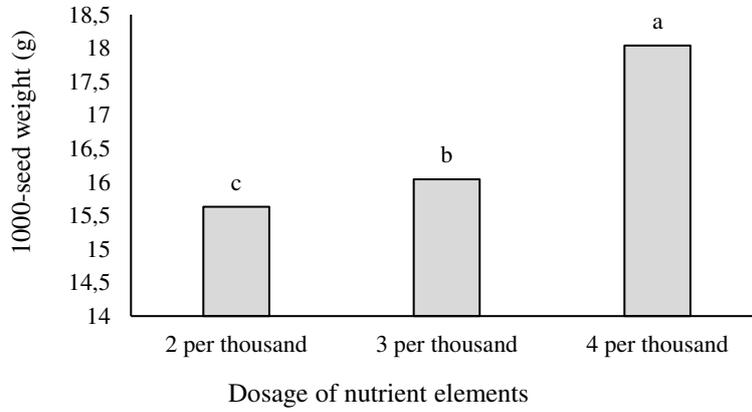


Figure 7. Mean comparison of different concentrations of foliar application on 1000-seed weight of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 7. Boyotu bitkisinde yapraktan uygulanan farklı element dozlarına ait bin tane ağırlığı ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

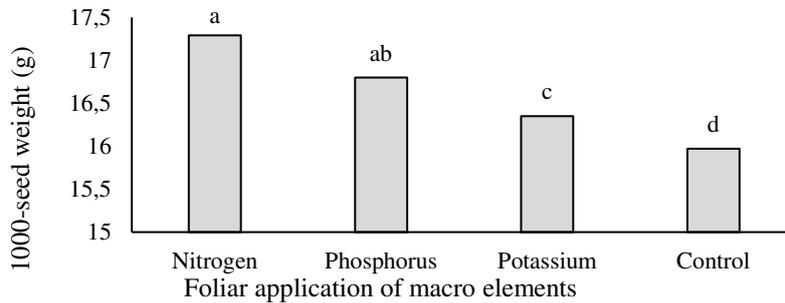


Figure 8. Mean comparison of different elements foliar application on 1000-seed weight of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 8. Boyotu bitkisinde yapraktan uygulanan farklı elementlerine ait bin tane ağırlığı ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

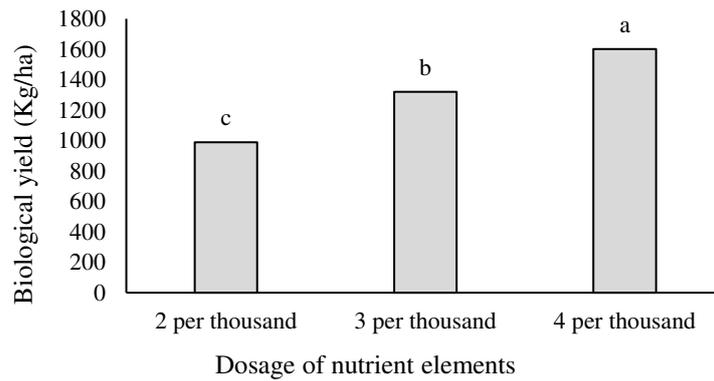


Figure 9. Mean comparison of different concentrations of foliar application on biological yield of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.
Şekil 9. Boyotu bitkisinde yapraktan uygulanan farklı element dozlarına ait biyolojik verim ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

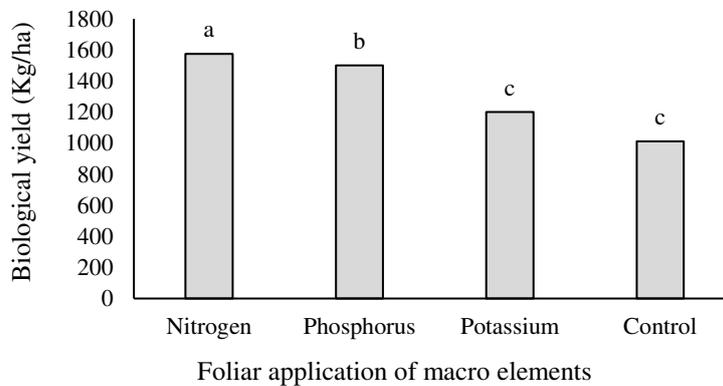


Figure 10. Mean comparison of different elements foliar application on biological yield of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.
Şekil 10. Boyotu bitkisinde yapraktan uygulanan farklı elementlerine ait biyolojik verim ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

3.7. Grain yield (kg/ha)

From the data in table 1, it is apparent that the foliar application of macronutrient had a significant effect ($p \leq 0.01$) on grain yield, however, the dosage treatments did not have a significant effect on grain yield. The mean comparison traits showed that the highest ($1029.2 \text{ kg} \cdot \text{ha}^{-1}$) grain yield was nitrogen treatment, and the lowest ($549.8 \text{ kg} \cdot \text{ha}^{-1}$) was observed in the control treatment (Fig. 11). Achieving the best grain yield

requires a proper balance between the capacity of the photosynthetic apparatus and its continuity, the rate of photosynthesis, the transfer and distribution rate of assimilates to the organs, the grain size, number, and their capacity for photosynthetic accumulation. Stem stock mobility, which involves photosynthetic surplus production, before the grain filling stage, is largely contributing to grain yield (Hasanzadehgorttpeh and Ghiyasi., 2008).

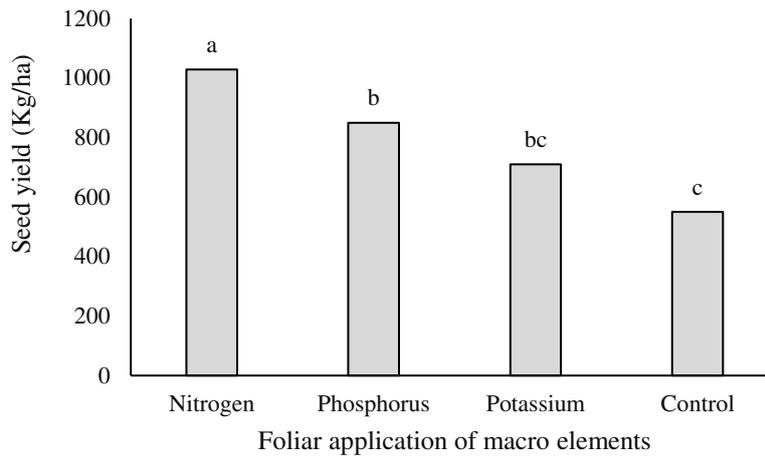


Figure 11. Mean comparison of different elements foliar application on seed yield of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 11. Boyotu bitkisinde yapraktan uygulanan farklı elementlerine ait tane verimi ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

The reason for increased yield in nitrogen applied treatments compared to control is a fact that nitrogen-treated plants expanded their root system in shorter times and produce additional biomass by more absorption of water, nutrition and formation of photosynthetic green areas. In plants treated with nitrogen fertilizers, increased invertase (which is responsible for the hydrolysis of sucrose) in the tip of the main stem, as well as in the lower parts, can release hexose from the internodes faster and increase the storage of sucrose in the grains in these plants. Also, the cause of increased yield can be attributed to increased activity of sucrose synthetize and sucrose phosphate synthetize enzymes in fertilizer treatments. Increased activity of sucrose phosphate synthetize in grain of treated plants can enhance the grain requirements to assimilates, which facilitates the grain filling of treated plants (Yang and Zhang., 2006).

3.8. Nitrogen percentage (%)

According to the analysis of variance table, the observed traits showed that macronutrient as well as dosage treatments had a significant effect on nitrogen percentage ($p \leq 0.01$) (Table 1). The mean comparison unveiled that the highest (1.34%) nitrogen percentage was detected in nitrogen treatments and the lowest (1.06%) was in control (Fig. 12). In terms of dosage treatments, the highest nitrogen content was observed in the doses 2 g/L (21.1%) and the lowest (15.1%) in the treatment with doses of 4 g/L (Fig. 13).

Enhancing the nitrogen content of wheat grain by nitrogen fertilizer application has also been reported by other researchers (Stuart et al., 2014). Hawkesford, (2014) investigated the effect of various sources and amounts of nitrogen on dry matter and absorption of macronutrients in sorghum and stated that the excess of nutrients reduced the absorption of nutrients, which is consistent with the results of this research.

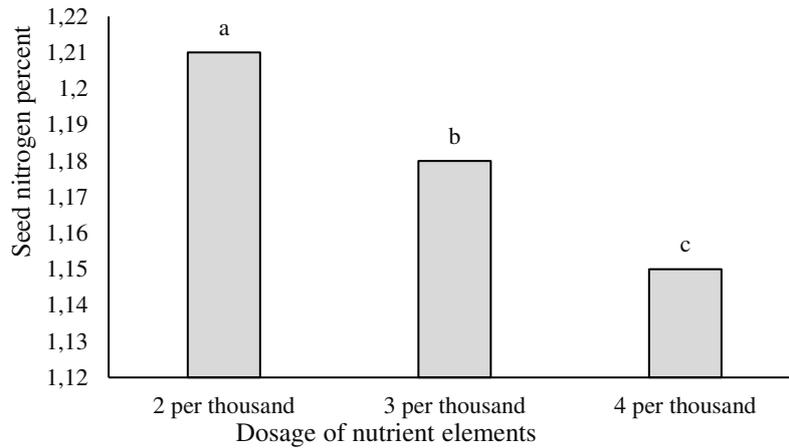


Figure 12. Mean comparison of different concentrations of foliar application on Seed nitrogen percent of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 12. Boyotu bitkisinde yapraktan uygulanan farklı element dozlarına ait tanede azot oranı ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

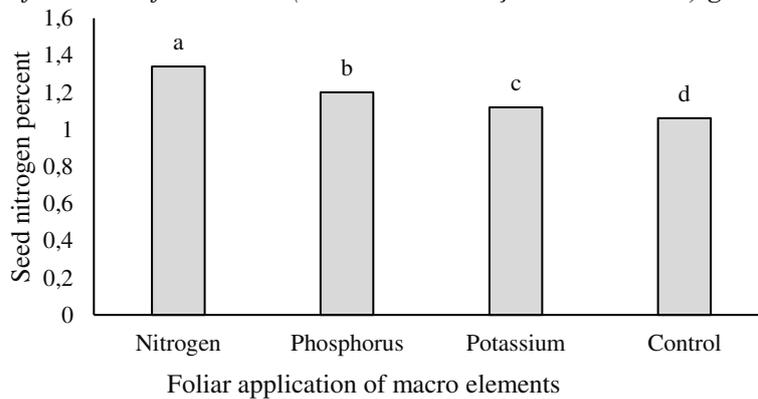


Figure 13. Mean comparison of different elements foliar application on seed nitrogen percentage of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 13. Boyotu bitkisinde yapraktan uygulanan farklı elementlerine ait tanede azot oranı ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

3.9. Protein percentage (%)

As table 1 shows, macronutrient and dosage treatments had a significant effect on the protein percentage ($p \leq 0.01$). Mean Comparison of studied traits displayed that the highest percentage of protein was associated to nitrogen treatment (12.4%) and lowest (9.85%) to control (Fig. 14). In dosage treatments the highest percentage of protein in 2 g/L (11.26%) and the lowest (10.64%) was observed in the dose of 4 g/L (Fig. 15). This result may be explained by the fact that nitrogen

fertilizers probably increased the amount of nitrogen imports from vegetative parts to grains compared to carbohydrates, thereby, increased the grain nitrogen concentration and protein content.

There are, however, other possible explanations for the reduction in the protein content of grain at a higher concentration (4 g/L). It can therefore be assumed that at high concentrations of fertilizer, a noteworthy portion of the total nitrogen content is stored in the form of nitrogen ions instead of amino acids or proteins (Styring et al., 2014).

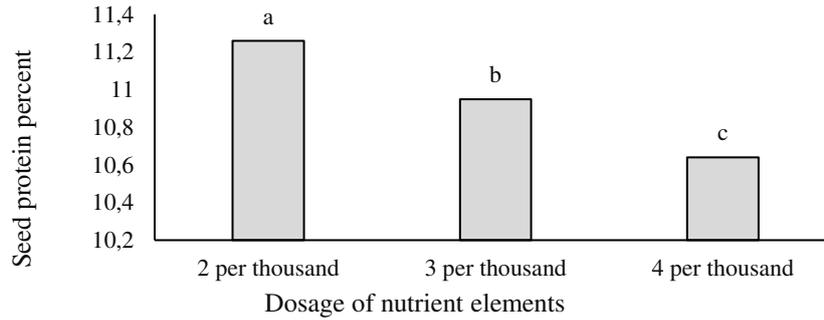


Figure 14. Mean comparison of different concentrations of foliar application on seed protein percent of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 14. Boyotu bitkisinde yapraktan uygulanan farklı element dozlarına ait tanede protein oranı ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

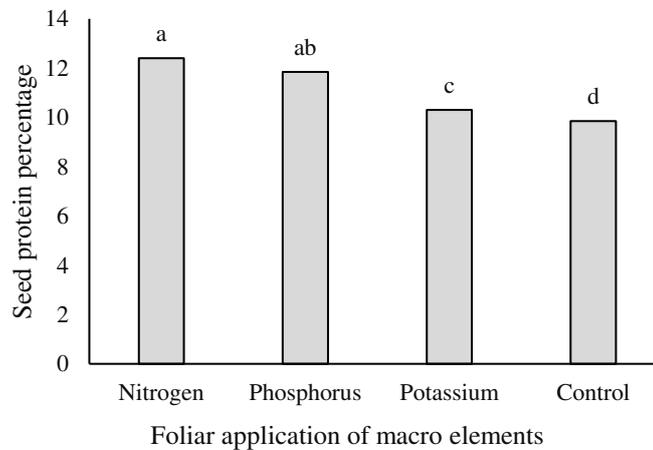


Figure 15. Mean comparison of different elements foliar application on seed protein percentage of Fenugreek. Different letters indicating significant differences at $P \leq 0.05$ in Duncan's Multiple Range test.

Şekil 15. Boyotu bitkisinde yapraktan uygulanan farklı elementlerine ait tanede protein oranı ortalama değerleri. Farklı harfler önemli farklılıkları ($P \leq 0.05$ Duncan Çoklu Aralık Test) göstermektedir.

Conclusion

The findings of this research provide insights for macronutrient foliar application as an effective method in the production and cultivation of medicinal plants. Foliar application could improve morpho-physiological characteristics, grain yield and protein percentage in fenugreek herb during its growth cycle in the climate and agro-ecosystem of marginal lands. Hence, the changes in the yield of fenugreek under the conditions of microelements foliar application are explained by variations in the number of pods per plant, pod length and 1000-seed weight. In sum up, spraying microelements assists to consider economic aspects and prevent

the soil nutrient imbalance, which is beneficial for sustainable agriculture policy.

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