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The Effects of Boron (B) and Phosphorus (P) Applications on Some Plant Characteristics in Cowpea (*Vigna unguiculata* L.)

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Abstract

In this study, conducted in the District of Ordu Province in 2021, the objective was to investigate the impacts of varying doses of P and B on key plant characteristics of cowpea (*Vigna unguiculata* L.) under typical farming conditions. The experiment followed a randomized block design with three replications. The Amazon cowpea variety was selected. Phosphorus doses ranged from 0 to 80 kg ha^{-1} (0, 40, 60, 80), while Boron doses (as P_2O_5) varied from 0 to 6000 g ha^{-1} (0-1500-3000-6000). The findings revealed significant variations among treatments. The flowering period ranged from 56 to 75 days, with the first pod height between 24.66 and 29.13 cm. Pod dimensions varied, with lengths spanning 14.92 to 17.88 cm and widths from 5.28 to 7.54 mm. Seed yield per plant showed a range of 26.74 to 38.99 g/plant, while harvest index ranged from 13.22 to 24.47%. Additionally, the number of nodules per plant ranged from 9.26 to 42.53. In the results of this study, there were statistically significant (P<0.01) differences between the applications in the examined properties. The application of 3000 g ha^{-1} Boron and 60 kg ha^{-1} Phosphorus in the fertilization of cowpea plants in Ordu ecological conditions is promising in terms of some plant properties.

Keywords: boron, cowpea, phosphorus, plant characteristics

Bor (B) ve Fosfor (P) Uygulamalarının Börülcede (*Vigna unguiculata* L.) Bazı Bitki Özellikleri Üzerine Etkileri

Öz

Bu çalışma, 2021 yılında Ordu ili çiftçi koşullarında farklı dozlarda bor ve fosfor uygulamalarının börülce (Vigna unguiculata L.) bitkisinin bazı bitkisel özellikleri üzerine etkisini belirlemek amacıyla yapılmıştır. Araştırma, tesadüf blokları deneme planına göre 3 tekrarlı olarak yapılmıştır. Çalışmada, amazon börülce çeşidi kullanılmıştır. Fosfor dozları 0, 40, 60, 80 kg/ha P2O5, bor dozları ise 0-1500-3000-6000 g/ha olarak uygulanmıştır. Araştırma sonucunda çiçeklenme süresi 56-75 gün, ilk bakla yüksekliği 24.66-29.13 cm, bakla boyu 14.92-17.88 cm, bakla genişliği 5.28-7.54 mm, bitki tane verimi 26.74-38.99 g, hasat indeksi % 13.22-24.47 ve bitkide nodül sayısı 9.26-42.53 adet olarak belirlenmiştir. Verilere göre, incelenen paremetrelerde uygulamalar arasında istatistiksel olarak çok önemli (P<0.01) farklar çıkmıştır. Ordu ekolojik koşullarında börülce bitkisinin gübrelemesinde 60 kg/ha fosfor ve 3000 g/ha bor uygulamasının bazı bitkisel özellikler bakımından ümitvar olduğu görülmüştür.

Anahtar Kelimeler: bor, börülce, fosfor, bitkisel özellikler

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Introduction

Cowpea is a significant legume crop that serves dual purposes: it can be consumed as food by humans and also used as fodder for animals (Debnath et al., 2018). Its homeland is South Asia, India and Africa (Ünlü and Padem, 2005). A large amount of production is carried out especially in the semi-arid areas of Africa (Afiukwa et al., 2013). Similar to beans in its consumption habits, cowpea is an adaptable crop that consumers can easily incorporate into their diets, especially in areas where bean cultivation is popular (Özkorkmaz & Yılmaz, 2017).

According to 2020 data in the world, the approximate cultivation area of cowpea is 11.3 million hectares, its production is 5.7 million tons and its yield per decare are 50.5 kg (FAO, 2020). In Turkey, the cultivation area is 1.9 thousand ha, production is 2.4 thousand tons, and the yield is 1030 kg per hectare. The reason for the low cowpea cultivation area in Türkiye may be that this plant is not well known as human food in our country (Sert, 2011).

The most common growing areas in our country are limited areas in the Aegean, Mediterranean and Southeastern Anatolia. Cowpea is grown in small amounts in the western and central parts of the Black Sea region, in districts such as Sinop, Kastamonu and Samsun's Çarşamba and Tekkeköy, and is marketed directly by farmers in local markets (Çulha & Bozoğlu, 2017).

To be successful in plant production, cultural measures must be applied correctly and when necessary. The genetic potential of the cultivated plant, environmental conditions and cultural processes are the factors that affect the amount of product (Bozbek & Ünay, 2005).

Fertilization is a key agricultural practice that significantly impacts soil fertility and crop yields. Nutrient imbalances can obstruct the uptake of essential elements by plants, leading to reduced yield and quality, as noted by Çimrin and Boysan (2006).

Phosphorus, present in soils as various phosphates and in apatite forms, is vital for plant growth, enhancing root development, maturation, seed formation, and bolstering disease and pest resistance, as described by Bilen and Sezen (1993).

Phosphorus also positively influences the nitrogen-fixing capabilities of symbiotic bacteria in legumes, allowing them to fix atmospheric nitrogen more efficiently. A deficiency in Phosphorus results in stunted growth of the plant's aerial parts and a compensatory increase in root development.

The functions of boron in plants can be listed as cell wall formation, root growth, flowering and fruit setting, nodule formation and nitrogen fixation. Boron deficiency especially affects the active points of the root and green parts. Deformations and yellowing may occur in young leaves. Symptoms are rarely seen on older leaves, but in advanced stages of the deficiency, symptoms may also be seen on leaves other than young leaves (Güneş et al., 2017). In paticular, nodüle formation in the plant and nitrogen fixation in the roots are negatively affected by B deficiency (Özkorkmaz & Yılmaz, 2023).

Boron deficiency is most commonly seen in acid soil conditions and humid places such as the Black Sea Region in Türkiye (Gülümser et al., 2005).

In this study, it was aimed to determine the effects of phosphorus and boron elements, which play an important role in the growth of plants in Ordu ecological conditions, on some vegetative properties of cowpea.

Material and Methods

Material

The research was carried out in the Ünye District of Ordu Province during the spring-summer season of 2021, under conditions typical for local farmers. The experimental site is situated in the Central Black Sea region at an elevation of 15 meters.

Over the long-term growth period for cowpea, the total rainfall at the site averages 474.20 mm, with a mean temperature of 19.80°C and average humidity of 74.37%. In the year 2021, the area received 540.8 mm of rainfall, the average temperature was slightly higher at 21.20°C, and the humidity increased to 77.92%, according to Anonymous (2021). These figures suggest that the rainfall was adequate for the cowpea's growth period.

Before sowing, soil samples were collected from various locations within the 0-30 cm depth range of the field and analyzed. The soil at the trial site was found to be slightly alkaline, falling within the ideal pH range for Phosphorus availability to plants. The soil's organic matter content was low, and it had a moderate level of lime. Nitrogen and potassium, which are essential for cowpea cultivation but were deficient in the soil, were added during planting. The soil's mechanical structure was identified as sandy-clay loam, a subclass of loamy soils.

For the study, the Amazon cowpea variety, which was added to the national variety list in 2010, was utilized as the plant material. In the experiment, the potassium source as fertilizer was potassium sulfate (in the form of K_2O) containing 50% potassium, the nitrogen source was urea containing 46% nitrogen, the Bor source was Etidot-67 (in the form of B_2O_3 boroxide) containing 20.8% Boron, and the Phosphorus source was Triple Super Phosphate containing 43% Phosphorus fertilizers were used.

Methods

The first tilling of the trial was made in early spring at a depth of 20-25 cm. To prepare the seed bed before planting, soil cultivation was tilled again at a depth of 10 cm.

The study was conducted to factorial arrangement in randomized blocks design with three replications. The parcel consists of 5 rows with a length of 3 m and a width of 2.5 m. The sowns were sown 50 cm between rows and 15 cm spacing between plants and a depth of 4-5 cm on May 20, Fertilizer was applied to each parcel along with sowing a the rate of 30 kg N ha^{-1} and 100 kg K ha^{-1}. Applications of Bor and Phosphorus were incorporated into the soil at the time of planting. Phosphorus, in the form of P_2O_5, was at rates recommended of 0, 40, 60, 80 kg ha^{-1}, while Boron was applied at 0, 1500, 3000, 6000 g ha^{-1}. The Bor treatments were diluted in 5 liters of water per plot before soil application. Triple super phosphate served as the Phosphorus source, and Boron oxide (B_2O_3) as the Boron source.

Plants was harvested manually (3 m^2) when color of pods turns from green to yellow 10 plants per plot were randomly selected for plant measurements and observation. Harvesting was manually executed, discarding one row at the plot's edges and the initial 0.5 m, aligning with the pods' transition to a straw yellow color. Post-harvest, the pods were left to dry, after which the seeds were manually extracted. For the assessment, 10 plants were randomly selected from each plot for measurements and observations.

Observations were taken days to flowering (days), the first pod height (cm), pod length (cm), pod width (mm), seed yield per plant (g), harvest index (%) and number of nodules per plant.

Data analyzed in SAS-JMP.13.0 statistical package program for variance analisis means were tested in LSD multiple comparison test.

Result and Discussion

Flowering Time (days)

Flowering time is an important feature in terms of cultivation. It is both a species characteristic and a feature that can change with environmental conditions.

The mean values effects of different Phosphorus and Boron fertilizer applications on the flowering time of the cowpea were given in Table 1.

Table 1. The Flowering Time with Different of Boron and Phosphorus Applications in Cowpea* (Day)

		Phosphorus Doses kg ha^{-1}				
		0	40	60	80	B avg.
Boron	0	71.00 bc	65.00 d	59.00 ef	70.00 c	66.25 B
Doses	1500	69.00 cd	66.00 d	58.00 ef	66.00 d	64.75 D
(g ha^{-1})	3000	61.00 e	59.33 ef	56.00 ef	70.33 c	61.66 C
	6000	75.00 a	64.66 d	70.33 c	74.00 ab	71.00 A
P avg.		69.00 A	63.75 B	60.75 C	67.58 A	

** Means in the same column with different letters differ statistically at 0.05 and 0.01 probability level according to LSD.*

In this study, the duration of cowpea flowering ranged from 56 to 75 days. The maximum flowering time of 75 days occurred in plots treated with 6000 g ha^{-1} of Boron without Phosphorus, while the minimum of 56 days was noted in plots receiving 3000 g ha^{-1} of Boron and 60 kg ha^{-1} of Phosphorus Previous research by Quddus et al. (2011) observed a decrease in flowering time with higher Boron levels, and Hada et al. (2014) found that Boron applications could shorten flowering by 2-3 days. Our results align with these findings to some extent, showing that Boron up to 3000 g ha^{-1} and Phosphorus up to 60 kg ha^{-1} reduced flowering time before it began to increase again.

On the other hand, the flowering period were found of Idikut et al. (2019), 49.00- 79.00 days; Kır et al. (2015), 60-93 days; Özkorkmaz (2020), 47.00-62.00 days; Özçelebi and Erman (2021) reported that it varied between 45.5 and 56.3 days.

The results we obtained were partially similar to the other reported results. The reason for the difference is thought to be soil structure, climate difference, cultivar and application methods.

Cowpea plant is a hot climate plant and is grown in the Aegean and Mediterranean regions of our country. The fact that the Black Sea region, where our study was conducted, is a region with high rainfall caused the flowering period to be extended.

First Pod Height (cm)

The averages and statistical groups of the affects of Boron and Phosphorus applications on the first pod height of cowpeas are showed in Table 2.

As can be seen from the table, the effect of Phosphorus, Boron and Boron and Phosphorus intraction on the first pod height was found to be statistically significant ($P<0.01$).

Table 2. Averages and Statistical Groups of The First Pod Height (Cm) of Boron and Phosphorus Applications in Cowpeas*

		Phosphorus Doses kg ha^{-1}				
		0	40	60	80	B avg.
Boron	0	24.66 f	27.46 bc	26.36 d	24.90 f	25.85 C
Doses	1500	29.10 a	26.03 de	28.36 ab	27.46 bc	27.74 A
(g ha^{-1})	3000	25.23 ef	29.13 a	28.96 a	26.56 cd	27.47 AB
	6000	26.46 cd	28.70 a	28.36 ab	24.76 f	27.07 B
P avg.		26.36 B	27.83 A	28.01 A	25.92 B	

** Means in the same column with different letters differ statistically at 0.05 and 0.01 probability level according to LSD.*

The height of the first pods varied between 24.66-29.13 cm, and the highest 29.13 cm was obtained from the parcels where Boron was applied at 3000 g ha^{-1} and Phosphorus at 40 kg ha^{-1}. However, parcels with 3000 g ha^{-1} of Boron and 60 kg ha^{-1} of Phosphorus, parcels with 6000 g ha^{-1} of Boron and

40 kg ha^{-1} of Phosphorus and parcels with 1500 g ha^{-1} of Boron and no Phosphorus were included in the same group. The shortest first pod height was determined to be 24.66 cm from the control plots where no application was made. It was observed that Boron and Phosphorus applications increased the first pod height, but after 3000 g ha^{-1} Boron and 6000 kg ha^{-1} Phosphorus applications, the first pod height decreased.

The first pod height is important in reducing harvest losses in the machine harvesting of cowpeas. Therefore, the first pod height should'n be too low.

Pekşen (2007) reported that the height of the first pod in cowpea plants is between 21.10-30.80 cm and that fertilization increases the height of the first pod up to a point.

On the other hand, Beycioğlu (2016) defines the height of the first pod as between 16.70-31.77 cm; Pekşen and Artı (2004), between 26.33 and 43.83 cm; Başaran et al. (2011) found that it varies between 36.50-63.2 cm. The results we obtained were partially similar to those ofother studies. It is thought that the difference arises from differences in soil structure, variety and application methods.

Pod Length (cm)

The averages and statistical groups regarding the effects of Boron and Phosphorus applications on pod length in cowpeas are given in Table 3.

As seen in Table 3, the effect of Phosphorus, Boron and Borob and Phosphorus intraction on pod length was determined to be significant (P<0.01).

Table 3. Averages and Statistical Groups Regarding The Length (Cm) of Boron and Phosphorus Applications in Cowpeas and Broad Beans*

		Phosphorus Doses kg ha^{-1}				
		0	40	60	80	B avg.
Boron	0	15.96 bc	16.00 bc	17.88 a	15.05 c	16.22 B
Doses	1500	17.17 ab	15.98 c	17.12 ab	14.92 c	16.29 B
(g ha^{-1})	3000	17.10 ab	16.76 ab	16.40 b	16.94 ab	16.80 AB
	6000	16.46 b	16.98 ab	17.70 a	16.77 ab	16.98 A
P avg.		16.67 AB	16.43 BC	17.27 A	15.92	

** Means in the same column with different letters differ statistically at 0.05 and 0.01 probability level according to LSD.*

It has been observed that the average length of pods in cowpeas varies between 14.92-17.88 cm. The longest pod length, 17.88 cm, was determined from the parcel where 60 kg ha^{-1} Phosphorus was applied and Boron was not applied, and the shortest pod length, 14.92 cm, was determined from the parcel where 1500 g ha^{-1} Boron and 80 kg ha^{-1} Phosphorus were applied. Increasing Boron doses increased pod length. Increasing Phosphorus doses increased pod length up to 60 kg ha^{-1}, and a shortening in pod length was observed at a dose of 80 kg ha^{-1}. On the other hand, 60 kg ha^{-1} Phosphorus and 6000 g ha^{-1} Boron application and no Boron application and 60 kg ha^{-1} Phosphorus application were in the same group and the longest pod length was obtained.

Toy and Ünlü (2015), stated that pod lengths vary between 12.0-15.6 cm and that the effect of increasing B doses on pod length in cowpeas is statistically significant and that as the amount of B increases, pod length increases up to a point. Ünlü and Padem (2005) reported that pod length varied between 10.97-18.47 cm and that increasing B doses increased pod length up to a point. It seems that our findings are compatible with the results of the researchers.

Looking at different studies, Pal et al. (2014), pod length is 2.6-18 cm; Prasanthi et al. (2012), 7.4-25 cm; Egbe et al. (2010), 8.75-20.27 cm; Khan et al. (2010) stated that it varies between 10-38 cm and that pod length in cowpea has a wide variation.

On the other hand, pod length, Stoilova and Pereira (2013), 9.80-17.70 cm; Bisikwa et al. (2014), 10.45-17.80 cm; Musvosvi (2009), 18.0–25 cm and Idahosa et al. (2010) reported it as 10.57-18.85 cm.

It was observed that the results we obtained were compatible with the results found by other researchers. Some studies have shown that there are differences, and it is thought that the reason for this difference may be soil structure, application methods and climate differences.

Pod Width (mm)

The averages and statistical groups regarding the effects of Boron and Phosphorus applications on pod width in cowpeas are given in Table 4.

As can be seen from the table, the effect of Phosphorus, Boron and Boron and Phosphorus intraction on pod width was determined to be significant (P<0.01).

Table 4. Averages and Statistical Groups of Pod Width (Mm) of Boron and Phosphorus Applications in Cowpeas*

		Phosphorus Doses kg ha^{-1}				
		0	40	60	80	B avg.
Boron	0	5.28 ı	6.75 efgh	6.62 gh	6.86 defgh	6.38 C
Doses	1500	6.99 cdefg	7.00 bcdefg	7.20 abcd	6.70 fgh	6.97 B
(g ha^{-1})	3000	7.33 abc	7.43 ab	7.54 a	7.00 bcdefg	7.33 A
	6000	7.17 abcde	7.07 bcdef	7.17 abcde	6.48 h	6.97 B
P avg.		6.69 B	7.06 A	7,13 A	6,76 B	

** Means in the same column with different letters differ statistically at 0.05 and 0.01 probability level according to LSD.*

The pod width of cowpea in this experiment showed variation, ranging from 5.28 mm to 7.54 mm. The widest pods, measuring 7.54 mm, were produced with a combination of 3000 g ha^{-1} Boron and 60 kg ha^{-1} Phosphorus, while the narrowest, at 5.28 mm, were observed in the control group without any fertilization. It was found that Boron increased pod width up to a dose of 3000 g ha^{-1}, beyond which the width decreased, and a similar pattern was noted with Phosphorus, where pod width increased up to a dose of 60 kg ha^{-1} before decreasing.

Comparing these findings with previous research, Ünlü and Padem (2005) reported pod widths ranging from 5.05 mm to 8.78 mm. Toy and Ünlü (2015) found pod widths between 6.8 mm and 8.3 mm, Bilen et al. (2020) recorded widths from 6.37 mm to 8.99 mm, and Karaman and Türkay (2021) observed a range of 7.30 mm to 9.31 mm. The results of this study align well with these earlier findings, indicating consistency across different research efforts.

Seed Yield Per Plant (g)

The Table 5 presents the mean values and statistical groupings for the yield per cowpea plant resulting from various Boron and Phosphorus treatments. The data indicate that both Phosphorus and Boron individually have a statistically significant impact on the yield per plant (P<0.01). Additionally, the interaction between Boron and Phosphorus also significantly influences the yield, albeit to a lesser extent (P<0.05).

Table 5. Averages and statistical groups of seed yield per plant (g/plant) of Boron and Phosphorus applications in cowpea*

		Phosphorus Doses kg ha^{-1}				
		0	40	60	80	B avg.
Boron	0	27.76 ef	31.90 bc	34.12 b	31.06 cd	31.21 B
Doses	1500	30.51 cde	32.10 bc	31.87 bc	29.79 cde	31.07 B
(g ha^{-1})	3000	32.28 bc	38.16 a	38.99 a	34.51 b	35.99 A
	6000	28.48 def	30.50 cde	27.77 ef	26.74 f	28.37 C
P avg.		29.76 B	33.16 A	33.19 A	30.52 B	

** Means in the same column with different letters differ statistically at 0.05 and 0.01 probability level according to LSD.*

Seed yield per plant varied between 26.74-38.99 g. The highest single plant grain yield in cowpea, 38.99 g, was obtained from the application of Boron at 3000 g ha^{-1} and Phosphorus at 60 kg ha^{-1}, and the lowest, 26.74 g, was obtained from the application of Boron dose at 6000 g ha^{-1} and Phosphorus dose at 80 kg ha^{-1}. The interaction of 3000 g ha^{-1} Boron and 60 kg ha^{-1} Phosphorus and the interaction of 3000 g ha^{-1} Boron and 40 kg ha^{-1} Phosphorus were in the same group and created the highest seed yield per plant. A decrease was observed in the doses after the application of 3000 g ha^{-1} of Boron. A decrease was also observed in the parcels where Phosphorus was applied after the dose of 60 kg ha^{-1}. It has been observed that increasing Boron and Phosphorus doses have an increasing effect on seed yield per plant up to a point and then decrease.

Movalia et al. (2018) reported in their study that increasing Boron doses increased grain yield up to a point, but at the highest dose there was a decrease in grain yield. The researchers' findings are consistent with our findings.

On the other hand, Özturan and Gülümser (2004) reported that grain yield per plant as 22-69 g; Erdoğan (2019) reported that it ranged between 14.26-22.48 g and Akdağ (1995) reported that it ranged between 19.22-42.28 g. It seems that the results obtained from our study are compatible with the results obtained by other researchers.

On the other hand, Toğay et al. (2014), 3.75- 7.00 g; Aremu (2011), 5-9 g; Yıldırım (2018), 4.5-7.70 g and İdikut et al. (2019) reported it as 3.75-24.02 g, and it was seen that they had a lower grain yield per plant than our study.

Harvest Index (%)

The averages and statistical groups of harvest index of Boron and Phosphorus applications in cowpea plants are given in Table 6.

As can be seen from the table, the effect of Phosphorus, Boron and Boron and Phosphorus intraction on the harvest index of cowpea was detected to be significant ($P<0.05$).

When the average harvest index of the cowpea plant was examined, it was seen that it varied between 13.22-24.47%. The highest harvest index, 24.47%, was gained the dose of 3000 g ha^{-1} of Boron and 40 kg ha^{-1} of Phosphorus, and the lowest, with 13.22%, was gained the dose of 1500 g ha^{-1} of Boron and 80 kg ha^{-1} of Phosphorus. It was observed that increasing Boron doses increased the harvest index up to 3000 g ha^{-1}, and the harvest index decreased at the dose of 6000 g ha^{-1}. In Phosphorus applications, 40 kg ha^{-1} dose gave the highest harvest index value and it was determined that there was a decrease as the doses increased.

Table 6. Averages and statistical groups of harvest index (%) of Boron and Phosphorus applications in cowpea*

		Phosphorus Doses kg ha^{-1}				
		0	40	60	80	B avg.
Boron	0	20.82 b	18.54 cd	18.62 c	14.42 gh	18.10 B
Doses	1500	18.78 c	22.13 b	14.93 fg	13.22 h	17.26 C
(g ha^{-1})	3000	20.79 b	24.47 a	21.07 b	16.14 ef	20.61 A
	6000	17.11 e	19.39 c	17.17 de	17.18 de	17.71 BC
P avg.		19.37 B	21.13 A	17.95 C	15.24 D	

** Means in the same column with different letters differ statistically at 0.05 and 0.01 probability level according to LSD.*

On the other hand, the harvest index from previous studies, El Naim et al. (2010), 7.0% - 28.3%; Toğay et al. (2014), 35.8%-35.9%; Akdağ (1995) stated that it varies between 26.3%-40.0% and Erdoğan (2019) varies between 24.5%-39.0%. Additionally, Öztürk (2010) reported the harvest index as 34%-65.2% in Ordu ecological conditions and Pekşen (2007) reported it as 46.24%-57.74% in Samsun conditions.

The results obtained in our study are partially similar to the results found by other researchers. The reason for some of the differences is thought to be variety, climate and cultural practices. Likewise, the harvest index, in addition to being a variety characteristic, varies significantly depending on environmental and climatic conditions, growing methods and planting time.

Number of Nodules Per Plant

The averages and statistical groups of the number of nodules in cowpea plants of Boron and Phosphorus applications were given in Table 7.

As indicated in Table 7, the influence of Boron, as well as the combined effect of Boron and Phosphorus, on the nodule count in cowpea was found to be significant ($P<0.01$), whereas the impact of P alone was not significant.

Table 7. Averages and Statistical Groups of the Number of Nodules (Number/Plant) in Cowpea of Boron and Phosphorus Applications*

		Phosphorus Doses kg ha^{-1}				
		0	40	60	80	B avg.
Boron	0	12.50 def	10.33 ef	16.60 de	9.93 ef	12.34 C
Doses	1500	28.96 bc	15.56 def	41.70 a	11.36 def	24.40 B
(g ha^{-1})	3000	31.12 bc	35.93 ab	14.46 def	42.53 a	31.01 A
	6000	17.56 d	30.46 bc	9.26 f	26.40 c	20.92 B
P avg.		24.09	23.07	20.50	22.55	

** Means in the same column with different letters differ statistically at 0.05 and 0.01 probability level according to LSD.*

When the average number of nodules of the cowpea plant was examined, it was seen that it varied between 9.26-42.53. The highest number of nodules per plant, 42.53, was obtained from 80 kg ha^{-1} dose of Phosphorus and 3000 g ha^{-1} dose of Boron, and the lowest, 9.26, was obtained from 60 kg ha^{-1} dose of Phosphorus and 6000 g ha^{-1} dose of Boron. As the Boron doses increased, the number of nodules increased up to the dose of 3000 g ha^{-1} and started to decrease at the dose of 6000 g ha^{-1}. The effect of P applications was insignificant.

Kır et al. (2015) reported that the number of nodules in cowpea varied between 9-19. Chatterjee and Bandyopadhyay (2017) stated in their study that the number of nodules in cowpeas was between 11.64 and 12.34, and they reported that the number of nodules increased with the increase in Boron applications, and decreased at the highest Boron dose. Nadeem et al. (2018) reported that the number of nodules increased with increasing Phosphorus doses along with Phosphorus applications in cowpea. The results we obtained are similar to the results of the researchers.

Conclusion

The research conducted in 2021 in the Unye District of Ordu Province, Türkiye, aimed to determine the impact of varying doses of Boron and Phosphorus on the growth characteristics of cowpea (*Vigna unguiculata* L.). The findings indicated that applications of Boron up to 3000 g ha^{-1} and Phosphorus up to 60 kg ha^{-1} extended the flowering period and improved the first pod height, pod length, pod width, and seed yield per plant. However, these benefits diminished with higher doses. While Boron's influence on the harvest index was consistent, a decline was noted beyond a Phosphorus dose of 40 kg ha^{-1}. The maximum nodule count of 42.53 was achieved with 80 kg ha^{-1} of Phosphorus and 3000 g ha^{-1} of Boron. Consequently, the study suggests that applying 3000 g ha^{-1} of Boron and 60 kg ha^{-1} of Phosphorus is an effective fertilization strategy for cowpea plants in the ecological conditions of Ordu, showing promise for enhancing certain plant characteristics.

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Author Contribution

Nuri Yılmaz, determining the topic, writing the article. *Yunus Elmas,* conducting field trials.

Ethic

There are no ethical issues regarding the publication of this article.

Conflict of Interest

The authors state that they have no conflict of interest.

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