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# The Effect of Different Phosphorus Doses on Forage Yield and Related Traits in Some Hungarian Vetch Cultivars

## *Bazı Macar Fiğ Çeşitlerinde Farklı Fosfor Dozlarının Ot Verimi ve İlgili Özellikler Üzerindeki Etkisi*

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**ABSTRACT**

The study was conducted to determine the effect of different levels of phosphorus on the forage yield and yield traits of some Hungarian vetch (*Vicia pannonica* Crantz.) culitvars. The experiment was set up using a Split Plot Experimental Design in Randomized Blocks with three replications in the Research Area of Dicle University Bismil Vocational School. The analysis indicated that phosphorus doses had a statistically significant impact ($P<0.05$) on some important traits. Due to the effect of the phosphorus doses, the examined traits displayed values within the following ranges: days to flowering (153.3-169.3 days), natual plant height (45.67-67.00 cm), main stem length (75.33-131.33 cm), main stems per plant (2.67-4.33), main stem thickness (1.77-2.17 mm), fresh forage yield (21.29-39.34 t $ha^{-1}$), and dry forage yield (5.86-10.39 t $ha^{-1}$). The research results revealed that the Kansur cultivar was more productive in terms of forage yield in Diyarbakır conditions. Additionally, there was no statistical significant difference in forage yield traits among the 30 kg $ha^{-1}$, 60 kg $ha^{-1}$, and 90 kg $ha^{-1}$ phosphorus dose treatments. Aditionally, forage yield obtained from these phosphorus dose treatments was higher than that of the control (0 dose) treatment, which recieved no phosphorus application.

**ÖZET**

Bu çalışma bazı Macar fiğ çeşitlerinde (*Vicia pannonica* Crantz.) farklı fosfor dozlarının ot verimi ve ilgili özellikler üzerindeki etkisini

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belirlemek amacıyla yürütülmüştür. Bu amaçla Dicle Üniversitesi Bismil Meslek Yüksekokulu Araştırma Arazisinde tarla denemesi, Tesadüf Bloklarında Bölünmüş Parseller Deneme Deseni kullanılarak düzenlenmiş ve üç tekrarlamalı olarak yürütülmüştür. Araştırma bulguları göre, istatiksel olarak incelenen önemli bazı özellikler yönünden önemli farklılıkların ($P<0.05$) oluştuğu saptanmıştır. Araştırmada kullanılan fosfor dozlarının etkisiyle Macar fiğ çeşitlerinde incelenen özelliklerin aşağıdaki şekilde değişim gösterdiği gözlemlenmiştir, %50 çiçeklenme gün sayısı 153.3-169.3 gün, doğal bitki boyu 45.67-67.00 cm, ana sap uzunluğu 75.33-131.33 cm, ana sap sayısı 2.67-4.33 sap bitki$^{-1}$, ana sap kalınlığı 1.77-2.17 mm, yeşil ot verimi 21.29-39.34 t ha$^{-1}$ ve kuru ot verimi 5.86-10.39 t ha$^{-1}$. Araştırma sonuçlarına göre; Diyarbakır ekolojik koşullarında ot verimi bakımından Kansur çeşidinin daha verimli olduğu tespit edilirken, fosfor dozları bakımından ise 30 kg ha$^{-1}$, 60 kg ha$^{-1}$ ve 90 kg ha$^{-1}$ fosfor dozu uygulamaları arasında yeşil ot verimi ve kuru ot verimi özellikleri bakımından istatiksel olarak fark olmadığı bu uygulamaların fosfor uygulanmamış kontrol dozu (0 doz) uygulamasına göre daha yüksek miktarlarda yeşil ot ve kuru ot verimi verdiği belirlenmiştir.

## 1. INTRODUCTION

A major challenge facing Türkiye's animal husbandry sector is the inadequate production of high-quality roughage for livestock existence of the country [1]. Annual forage legume species with shorter growing seasons are crucial for addressing this deficiency in quality roughage [2]. Incorporating these annual forage legumes in crop rotation systems not only supplies quality roughage but also contributes significantly to the sustainable management of agricultural lands. This practice enriches the soil with organic matter and nitrogen, enhancing soil fertility and promoting a healthier ecosystem [3]. Hungarian vetch (*Vicia pannonica* Crantz.) is annual plant species from legume family and recognized for its broad adaptability and widespread distribution globally [4]. It is particularly valued for its cold resistance, making it suitable for planting as a winter crop in regions with severe winter conditions. This characteristic allows it to supply high-quality forage in the colder ecological conditions [5,6]. As a result, Hungarian vetch has become one of the most widely cultivated annual forage plant species in Türkiye. In recent years, numerous new cultivars have been developed and recommended to farmers, further enhancing its popularity and utility in agricultural practices.

Nutrient availability for plants is a fundamental and extensive topic within the realm of soil chemistry. Similar to all living beings, plants require a diverse array of nutrients in varying amounts to thrive and survive effectively. A significant portion of the dry matter produced by plants through the process of photosynthesis consists of elements such as carbon, oxygen, and hydrogen, which are sourced from air and water. Since these elements are generally abundant under normal conditions, there are no negative situations in plants caused by their deficiency [7, 8]. However, most of the nutrients essential for plant growth are derived from the soil, and are categorized into two main groups: macronutrients and micronutrients, based on the amounts that plants absorb [9, 10].

Phosphorus, a crucial macronutrient for plant growth, constitutes approximately 0.01% to 0.05% of the plant dry matter weight [8, 11, 12]. Phosphorus plays vital functions in plants, including its presence in the structure of DNA, which is essential for determining the genetic make up of plants. It is also crucial for the formation of ATP (adenosine triphosphate), sugars, and nucleic acids, all of which are integral to energy transfer and metabolic processes. Furthermore, phosphorus plays a significant role in cell division, contributing to overall plant growth and development [13, 14]. Phosphorus is a key element in the generative development of plants, significantly influencing the formation of flowers, fruits, and seeds. In addition, phosphorus accelerates ripening, promotes early maturity and enhances the plant`s ability to absorb potassium element. Phosphorus element also regulates water intake of plant roots, improves wate use efficiency and increasing plant resistance against plant diseases and pests [8, 15].

Despite the mentioned important properties, mostly the amount of plant-available phosphorus ($P_2$ $O_5$ ) in the soil is often insufficient to meet the plant needs [16]. Acccordingly, It is important to apply phosphorus fertilization to avoid the negative effects caused by phosphorus deficiency in plants. Many researchers have reported that legume plants have a greater demand for phosphorus compared to other nutrients and respond positively to phosphorus fertilization [17, 18, 19, 20, 21]. The objective of this research is to examine the impact of varying phosphorus doses on forage production and yield traits in different cultivars of Hungarian vetch. In order to identify the cultivars with high forage yield and the optimal phosphorus dose for Diyarbakır and similar ecological conditions.

## 2. MATERIAL AND METHOD

The plant material of in this study consisted of four Hungarian vetch (*Vicia pannonica* Crantz.) cultivars Kansur, Akçalar, Anadolu Pembesi, and Sarı Efe. These cultivars have been registered and commercially utilized in Türkiye in recent years. On the other hand, in total of five different treatments were tested, including a control treatment with no phosphorus application (0 dose) and four varying phosphorus doses, 30 kg $ha^{-1}$, 60 kg $ha^{-1}$, 90 kg $ha^{-1}$ and 120 kg $ha^{-1}$. The required phosphorus doses were supplied by using Triple Super Phosphate (TSP- 44% $P_2O_5$) fertilizer at the time of sowing. Additionally, all plots in the research trial received 30 kg $ha^{-1}$ of pure nitrogen at sowing, applied through Urea (46% N) fertilizer.

**Table 1.** Climatic Characteristics of the Resaerch Area

| | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | Total Precipitation (mm) (Monthly) | | | | | | | | | | Total |
| 2022-23 | 0.7 | 25.2 | 97.8 | 4.7 | 17.9 | 57.6 | 131.0 | 79.4 | 16.0 | 0.0 | 430.3 |
| Long years | 5.4 | 33.0 | 55.2 | 72.4 | 70.7 | 67.6 | 66.7 | 70.0 | 44.4 | 8.7 | 494.1 |
| | Mean air temperature (°C) (Monthly) | | | | | | | | | | Mean |
| 2022-23 | 27.0 | 19.7 | 11.0 | 7.3 | 3.9 | 4.0 | 12.0 | 14.7 | 20.1 | 27.6 | 14.7 |
| Long years | 25.1 | 17.5 | 9.7 | 4.0 | 1.7 | 3.7 | 8.3 | 13.8 | 19.3 | 26.0 | 12.9 |
| | Mean relative humidity (%) (Monthly) | | | | | | | | | | Mean |
| 2022-23 | 27.6 | 46.1 | 77.9 | 82.1 | 75.9 | 62.9 | 67.4 | 65.8 | 49.6 | 34.3 | 59.0 |
| Long years | 30.8 | 48.1 | 66.6 | 76.3 | 77.0 | 72.8 | 66.5 | 64.0 | 56.7 | 36.4 | 59.5 |

The field trial for this research was conducted during the 2022-2023 growing season at the Research Area of Dicle University Bismil Vocational School. The site is located at an altitude of 541 meters, with geographic coordinates of 37°50'16"N and 40°38'52"E. The climatic characteristic of the resaerch place are detailed in Table 2. Upon examining Table 2, it was noted that the total precipitation during the 2022-23 growing season, , was lower than the long-term average.However, the amount of precipitation in March of the 2022 was approximately twice that of the same month in previous years. When the monthly average temperature and relative humidity values were analysed ; it was observed that the monthly average temperatures during the 2022-23 growing season were higher than the long-term average in all months, while relative humidity averages remained similar to the long-term average. Additionally, the climatic characteristics of the resaerch area was presented in the Table 2. Upon reviewing Table 2, it was observed that the soils of the research area were free of salt, had a loamy texture, and were neutral in pH. They exhibited low levels of organic matter and phosphorus but had adequate amounts of potassium and lime.

**Table 2.** Soil Analysis Results of the Research Area

| Debth (cm) | Texture | pH | Total Salt (%) | Lime (%) | Organic Matter (%) | $P_2O_5$ (kg $ha^{-1}$) | $K_2O$ (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| 0-30 | Loamy | 6,9 | 0,01 | 18,72 | 1,27 | 30,61 | 330,73 |

The research trial was conducted using a Split Plot in Randomized Blocks Design, with three replications. In this design, Hungarian vetch cultivars were assigned to the main plots, while varying doses of phosphorus were designated for the subplots. Each experimental plot consisted of four rows, each measuring 6 meters in length. The spacing between rows within the experimental plots was set at 25 cm. Furthermore, a 60 cm gap was maintained between individual experimental plots, and different

experimental blocks were seperateda distance of 2.5 meters. This layout aimed to ensure optimal growth conditions and minimize interference among treatments during the trial period. The sowing rate for the research was taken as 230 seeds per square meter. The research trial was sown on November 24, 2022, by placing seeds into furrows opened with a hand sowing tool in the tempered soil and covering them. During the trial period, the necessary maintenance was carried out completely and weed control was done manually. Forage harvesting of the plots were made at the full flowering period to the plants.

The traits investigated in this study were measured in accordance with the Official Technical Instructions [22] provided by the Seed Registration and Certification Centre of Türkiye. The data collected throughout the research were analyzed utilizing the JMP statistical software package. [23]. To assess significant differences among treatments, an F test was employed. Additionally, mean comparisons were conducted using LSD test at a 5% significance level. This statistical approach ensured reliable interpretation of the results and allowed for a thorough evaluation of the impact of various treatments on the investigated traits.

## 3. RESULTS AND DISCUSSION

Days to 50% flowering (DTF): The data regarding the DTF trait for various cultivars of Hungarian vetch (*Vicia pannonica* Crantz) subjected to different phosphorus dose treatments are summarized in Table 3. Statistical analysis revealed that the differences among the cultivars and various phosphorus doses were significant ($P<0.01$). However, no statistically significant interaction was found between the cultivars and phosphorus doses applied. Notably, the control treatment, which received no phosphorus (0 dose), recorded the highest number of days to reach 50% flowering. It was determined that increasing phosphorus doses reduced the time required to reach 50% flowering, thereby promoting early flowering. Consistent with our findings, Oncan Sumer and Erten [24] reported that phosphorus significantly accelerated the timing of the transition to the generative phase in plants, hastening their maturation. In the study, when examining the DTF trait across different Hungarian vetch cultivars, the earliest flowering was observed in the Anadolu Pembesi cultivar (154.8 days). The means of DTF trait detected in the other Hungarian vetch cultivars were found to be in the same statistical group (Table 3). The findings regarding DTF trait in Hungarian vetch were consistent with the results of Sayar [25], whereas the findings of Taş et al. [26], Hashalıcı et al. [27] and Koç [28] were found to be higher than findings of the study. Contrastly, findings of Sayar et al. [29] were lower than the study findings. A possible reason for the differences among the findings could be the varying climatic conditions of the locations where the studies were conducted.

**Table 3.** The Means of Days to 50% Flowering Trait in Hungarian Vetch Cultivars under the Effect of Different Phosphorus Doses Treatments

| | Days to 50% flowering (days) | | | | |
|---|---|---|---|---|---|
| Phosphorus doses (kg ha$^{-1}$) | Cultivars | | | | |
| | Kansur | Akçalar | Anadolu Pembesi | Sarı Efe | Mean |
| 0 | 169.3 | 167.7 | 156.3 | 167.0 | 165.1 A |
| 30 | 168.0 | 167.3 | 155.3 | 166.0 | 164.2 B |
| 60 | 167.7 | 167.3 | 154.7 | 165.3 | 163.8 B |
| 90 | 166.7 | 166.0 | 154.3 | 165.0 | 163.0 C |
| 120 | 165.0 | 165.0 | 153.3 | 164.7 | 162.0 D |
| Mean | 167.3 A | 166.7 A | 154.8 B | 165.6 A | 163.6 |
| CV (%) | 0.49 | | | | |
| LSD (0.05) Cultivars | 4.64** | | | | |
| LSD (0.05) P doses | 0.67** | | | | |
| LSD (0.05) C*P | ns | | | | |

**: Significant at the 0.01 level; ns: Statistically non-significant

**Table 4.** The Means of Natural Plant Height Trait in Hungarian Vetch Cultivars under the Effect of Different Phosphorus Doses Treatments

| | Natural plant height (cm) | | | | |
|---|---|---|---|---|---|
| Phosphorus doses (kg ha$^{-1}$) | Cultivars | | | | |
| | Kansur | Akçalar | Anadolu Pembesi | Sarı Efe | Mean |
| 0 | 61.33 | 48.25 | 59.83 | 54.00 | 55.85 |
| 30 | 67.00 | 51.33 | 55.33 | 51.33 | 56.25 |
| 60 | 65.67 | 48.67 | 51.67 | 49.00 | 53.75 |
| 90 | 62.00 | 46.67 | 49.00 | 45.67 | 50.83 |
| 120 | 65.67 | 49.33 | 47.33 | 47.33 | 52.42 |
| Mean | 64.33 A | 48.85 B | 52.63 B | 49.47 B | 53.82 |
| CV (%) | 9.79 | | | | |
| LSD (0.05) Cultivars | 4.58** | | | | |
| LSD (0.05) P Doses | ns | | | | |
| LSD (0.05) C*P | ns | | | | |

**: Significant at the 0.01 level; ns: Statistically non-significant

Natural plant height (NPH): Significant differences (P<0.01) for NPH trait were observed among the Hungarian vetch cultivars, with plants heights ranging from 48.85 cm to 64.33 cm. However, phosphorus doses and the interaction between cultivar and phosphorus had no significant effect (P>0.05). This aligns with Cebeci [30], who found no significant phosphorus effect on plant height. Kansur exhibited the tallest natural height. The observed plant heights are consistent with previous research on Hungarian vetch [29, 31, 32].

Main stem length (MSL): No significant differences (P>0.05) were found among Hungarian vetch cultivars, phosphorus doses, or their interaction regarding main stem length. However, observed main stem lengths varied from 81.54 cm to 131.33 cm across cultivars and phosphorus treatments (Table 5). The findings related to the MSL trait in Hungarian vetch cultivars in the study were fully

compatible with the MSL values reported by Taş et al. [26] for Hungarian vetch. However, the MSL values of the study were found to be partially compatible with those of cited by Sayar [29], and higher than the those of reported by Bağcı [31] and Koç [32] in Hungarian vetch species. The differences among the findings can be attributed to differences in the genotypes used and the ecological conditions of the studies.

**Table 5.** The Means of Main Stem Length Trait in Hungarian Vetch Cultivars under the Effect of Different Phosphorus Doses Treatments

| | Main stem length (cm) | | | | |
|---|---|---|---|---|---|
| Phosphorus doses (kg ha$^{-1}$) | Cultivars | | | | |
| | Kansur | Akçalar | Anadolu Pembesi | Sarı Efe | Mean |
| 0 | 99.33 | 90.25 | 81.54 | 120.33 | 97.86 |
| 30 | 121.00 | 110.00 | 83.00 | 113.33 | 106.83 |
| 60 | 119.33 | 104.33 | 75.33 | 126.67 | 106.42 |
| 90 | 101.67 | 106.00 | 83.33 | 111.67 | 100.67 |
| 120 | 131.33 | 110.67 | 84.00 | 119.00 | 111.25 |
| Mean | 114.53 | 104.25 | 81.44 | 118.20 | 104.61 |
| CV (%) | | | 13.64 | | |
| LSD (0.05) Cultivars | | | ns | | |
| LSD (0.05) P Doses | | | ns | | |
| LSD (0.05) C*P | | | ns | | |

ns: Statistically non-significant

Main stem numbers (MSN): Phosphorus doses and Hungarian vetch cultivars weren not significantly affectedby the applied phosphorus doses for MSN trait. Similarly, cultivar*phosphorus dose interaction was found to be statistically insignificant in terms of MSN trait (Table 6 ). Consistent with our research findings, Cebeci [30] reported that phosphorus doses and cultivar*phosphorus dose interactions were insignificant for MSN trait in Hungarian vetch. On the other hand, Fayetörbay et al. [6] reported that phosphorus doses provided higher main stems in Hungarian vetch compared to the control application with no phosphorus application, but there was no statistically significant difference between 55 kg ha$^{-1}$ phosphorus application and 100 kg ha$^{-1}$ phosphorus application for MSN trait. In addition, a statistically significant difference ($P<0.01$) was determined among the Hungarian vetch cultivars in terms of the number of main stems. The lowest number of main stems was found in the Sarı Efe cultivar, whilethe highest number was observed in the Anadolu Pembesi cultivar. Moreover, MSN means determined in Kansur and Akçalar cultivars were found to be statistically indistinguishable (Table 6). The means of main stem numbers for Hungarian vetch ranged from 2.67 to 4.33 among cultivars and phosphorus doses in the reasearch. It was determined that the findings regarding the number of main stems determined in our study were found to be similar to those of the following researchers findings determined in Hungarian vetch in various ecologies, Orak and Nizam [33] in Tekirdağ conditions, Bağcı [31] in Ankara conditions and Sayar [29] in Diyarbakır conditions.

**Table 6.** The Means of Main Stem Numbers per Plant Trait in Hungarian Vetch Cultivars under the Effect of Different Phosphorus Doses Treatments

| Phosphorus doses (kg ha$^{-1}$) | Main stem numbers per plant (stems plant$^{-1}$) | | | | |
|---|---|---|---|---|---|
| | Cultivars | | | | |
| | Kansur | Akçalar | Anadolu Pembesi | Sarı Efe | Mean |
| 0 | 3.00 | 4.33 | 4.33 | 3.00 | 3.67 |
| 30 | 3.33 | 3.00 | 4.00 | 3.67 | 3.50 |
| 60 | 3.67 | 4.00 | 4.33 | 2.67 | 3.67 |
| 90 | 3.00 | 3.67 | 4.00 | 3.00 | 3.42 |
| 120 | 3.33 | 2.67 | 4.00 | 3.00 | 3.25 |
| Mean | 3.27 BC | 3.53 B | 4.13 A | 3.07 C | 3.50 |
| CV (%) | 10.28 | | | | |
| LSD (0.05) Cultivars | 0.41** | | | | |
| LSD (0.05) P Doses | ns | | | | |
| LSD (0.05) C*P | ns | | | | |

**: Significant at the 0.01 level; ns: Statistically non-significant

The main stem thickness (MST): For MST trait statistically significant differences were observed at the 0.05 level for both Hungarian vetch cultivars and the phosphorus doses used, while the interaction between cultivars and phosphorus doses was found to be insignificant. Additionally, the study results showed that compared g to the control treatment (0 dose), the applied phosphorus doses treatments statistically significantly increased the MST of Hungarian vetch. However, no differences were found among the phosphorus doses (30 kg ha$^{-1}$, 60 kg ha$^{-1}$, 90 kg ha$^{-1}$ and 120 kg ha$^{-1}$), as they all belonged to the same statistical group in terms of MST trait (Table 7). Consistent with our research findings; Temel and Şahin [34] reported that phosphorus doses provided a significant increase in MST trait compared to the control dose, with no phosphorus (0 dose). When the MST means of Hungarian vetch cultivars examined from Table 7; the lowest MST was determined in Anadolu Pembesi cultivar, while the other Hungarian vetch cultivars fell into the same statistical group in terms of MST trait. The research MST trait means (1.77-2.20 mm), determined in Hungarian vetch cultivars and phosphorus doses, were e fully compatible with the findings of Bağcı [31] and Sayar et al. [29] and partially compatible with the findings of Cebeci [30].

Fresh forage yield (FFY): analysis of the FFY trait revealed that significant differences ($P<0.01$) among Hungarian vetch cultivars and significant differences ($P<0.05$) among phosphorus doses. However, no significant interaction was observed between cultivar and phosphorus treatment ($P>0.05$). Phosphorus applications of 30, 60, and 90 kg ha$^{-1}$ resulted in the highest yields, exceeding the control (0 kg/ha). Unexpectedly, the highest phosphorus application rate (120 kg/ha) produced lower yields than these intermediate rates. Accordingly, in previous studies, many researchers studying on different forage plant species have reported that applying phosphorus doses at certain rates positively affects photosynthesis in plants and helping vegetative parts develop better, thus increasing

FFY trait [34, 35, 36, 37]. Among the Hungarian vetch cultivars, Kansur exhibited the highest FFY, while Anadolu Pembesi showed the lowest (Table 8). FFY trait means determined in the study for Hungarian vetch cultivars under the different phosphorus doses were found to be similar to the FFY trait values reported by many researchers in Hungarian vetch species [25, 26, 38, 39].

**Table 7.** The Means of Main Stem Thickness Trait in Hungarian Vetch Cultivars under the Effect of Different Phosphorus Doses Treatments

| | Main stem thickness (mm) | | | | |
|---|---|---|---|---|---|
| Phosphorus doses (kg ha$^{-1}$) | Cultivars | | | | |
| | Kansur | Akçalar | Anadolu Pembesi | Sarı Efe | Mean |
| 0 | 1.93 | 2.07 | 1.77 | 1.87 | 1.91 B |
| 30 | 2.13 | 2.17 | 1.90 | 2.13 | 2.08 A |
| 60 | 2.07 | 1.93 | 1.93 | 2.23 | 2.04 A |
| 90 | 2.10 | 1.97 | 1.93 | 2.17 | 2.04 A |
| 120 | 2.07 | 2.20 | 1.93 | 2.17 | 2.09 A |
| Mean | 2.06 AB | 2.07 A | 1.89 B | 2.11 A | 2.03 |
| CV (%) | 6.89 | | | | |
| LSD (0.05) Cultivars | 0.14* | | | | |
| LSD (0.05) P Doses | 0.10* | | | | |
| LSD (0.05) C*P | ns | | | | |

**: Significant at the 0.01 level; ns: Statistically non-significant

Dry forage yield (DFY): Highly significant differences (P<0.01) were found among the Hungarian vetch cultivars for the DFY trait. Additionally, significant differences (P<0.05) were observed among the various phosphorus doses applied. In contrast, the interaction between cultivars and phosphorus doses was found to be insignificant (P>0.05). According to the research results, it was determined that the treatment phosphorus doses significantly increased dry forage yield in Hungarian vetch, compared to the control treatment, which received no no phosphorus application (0 dose). However, no statistical difference was found between phosphorus doses in terms of DFY trait. Consistent with our research findings, researchers working on different forage crops speices reported that phosphorus dose applications provided higher rates of DFY compared to the control (0 dose) treatment [34, 35, 36, ]. Hungarian vetch dry forage yields, as shown in Table 9, ranged from 5.86 to 10.39 t ha$^{-1}$. Kansur yielded the most, while Anadolu Pembesi produced the least dry forage. Our research findings were consistent with the DFY trait findings of the following researchers in different ecological conditions determined in Hungarian vetch species, Mihailovic et al. [38] in Serbia ecological conditions, Sayar et al. [40] in Diyarbakir ecological conditions and Siverek and Cacan [39] (2023) in Bingöl ecological conditions.

**Table 8.** The Means of Fresh Forage Yield Trait in Hungarian Vetch Cultivars under the Effect of Different Phosphorus Doses Treatments

| | Fresh forage yield (t ha$^{-1}$) | | | | |
|---|---|---|---|---|---|
| Phosphorus doses (kg ha$^{-1}$) | Cultivars | | | | |
| | Kansur | Akçalar | Anadolu Pembesi | Sarı Efe | Mean |
| 0 | 32.78 | 28.43 | 21.32 | 26.30 | 27.21 C |
| 30 | 34.77 | 27.65 | 23.17 | 30.38 | 28.99 A-C |
| 60 | 37.47 | 28.80 | 22.75 | 29.83 | 29.71 A-B |
| 90 | 39.34 | 29.77 | 21.29 | 32.73 | 30.78 A |
| 120 | 35.03 | 25.45 | 21.32 | 29.92 | 27.93 BC |
| Mean | 35.88 A | 28.02 B | 21.97 C | 29.83 B | |
| CV (%) | 13.04 | | | | |
| LSD (0.05) Cultivars | 0.58** | | | | |
| LSD (0.05) P Doses | 0.27* | | | | |
| LSD (0.05) C*P | ns | | | | |

**: Significant at the 0.01 level; ns: Statistically non-significant

**Table 9.** The Means of Dry Forage Yield Trait in Hungarian Vetch Cultivars under the Effect of Different Phosphorus Doses Treatments

| | Dry forage yield (t ha$^{-1}$) | | | | |
|---|---|---|---|---|---|
| Phosphorus doses (kg ha$^{-1}$) | Cultivars | | | | |
| | Kansur | Akçalar | Anadolu Pembesi | Sarı Efe | Mean |
| 0 | 8.48 | 7.43 | 5.86 | 7.23 | 7.25 B |
| 30 | 9.16 | 7.55 | 6.76 | 8.56 | 8.01 A |
| 60 | 10.11 | 7.69 | 6.41 | 8.45 | 8.17 A |
| 90 | 10.39 | 7.85 | 6.20 | 9.32 | 8.44 A |
| 120 | 10.06 | 7.24 | 6.18 | 8.99 | 8.12 A |
| Mean | 9.64 A | 7.55 BC | 6.28 C | 8.51 AB | |
| CV (%) | 11.02 | | | | |
| LSD (0.05) Cultivars | 0.165** | | | | |
| LSD (0.05) P Doses | 0.059* | | | | |
| LSD (0.05) C*P | ns | | | | |

**: Significant at the 0.01 level; ns: Statistically non-significant

## 4. CONCLUSION

High forage yield is a primary aim in forage crop production. Achieving this requires the optimal application of phosphorus, which plays a critical role. Phosphorus is an essential element in vital plant processes such as energy transfer, photosynthesis, and root development. Insufficient phosphorus slows plant growth, hinders root development, and consequently reduces forage yield. However, excessive phosphorus application can lead to economic losses and environmental problems (e.g., water pollution). Therefore, research to determine the optimal phosphorus dose for high forage yield is crucial. This research examined the impact of varying phosphorus levels on the forage yield and related traits of Hungarian vetch (*Vicia pannonica* Crantz.). The results indicated a statistically significant positive response ($P<0.05$) to phosphorus application across several key parameters,

including flowering time, stem thickness, fresh forage yield, and dry forage yield. The application of phosphorus not only accelerated flowering but also significantly enhanced both fresh and dry forage yields as well as stem thickness in Hungarian vetch cultivars. The research results indicated that the Kansur cultivar was more productive in terms of forage yield under the ecological conditions of Diyarbakır. Moreover, the forage yield obtained from phosphorus dose treatments was higher than that of the control (0 dose) treatment, which had no phosphorus application. However, no statistically significant difference was found among the 30 kg $ha^{-1}$, 60 kg $ha^{-1}$, and 90 kg $ha^{-1}$ phosphorus dose treatments in terms of fresh forage yield and dry forage yield traits.

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## CONFLICTS OF INTEREST

The authors declare that they have no competing interests or conflicts of interest to report.

## DECLARATION OF ETHICAL CODE

In this research, the authors confirm their compliance with the principles established in the “Higher Education Institutions Scientific Research and Publication Ethics Directive”. They also state that they have not participated in any actions classified as "Contrary to Scientific Research and Publication Ethics" as defined in the aforementioned directive.

## AUTHORS’ CONTRIBUTIONS

Berat ŞENYİĞİT: Responsible for collecting plant production materials, establishing the field experiment, maintaining experiments, conducting observations, reviewing literature, and organizing data. Mehmet Salih SAYAR: In charge of planning the study, conducting observations, performing statistical analysis of data, and writing the article.

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