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Determination of the Potential of Some Legume Forage Crops as Bee Pasture

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ABSTRACT

This study was carried out to investigate the potential of some cultivated legume forage crops to be used as bee pasture. Hungarian vetch (*Vicia pannonica* Crantz), sainfoin (*Onobrychis viciifolia* Scop.), and white clover (*Trifolium repens* L.) were used as plant materials. The study was conducted during the 2020/2021 and 2021/2022 growing seasons under the ecological conditions of Bingöl. In the first year, Hungarian vetch was the first plant visited by bees, while sainfoin and white clover were visited around the same time. In the second year, sainfoin was the first, followed closely by Hungarian vetch and white clover. Based on two-year averages, white clover was open to bee visitation for 54 days, sainfoin for 34 days, and Hungarian vetch for 16 days. The average number of honeybee visits over the two years was 19.9 in Hungarian vetch, 36.35 in sainfoin, and 39.65 in white clover. Differences in the number of bee visits, time spent on the flower, and the number of flowers per m² in 2021 and 2022 were statistically significant for all three forage crops. In 2021, plant height was found statistically insignificant. According to two-year average correlation data, the time bees spent on the flowers and the number of flowers per square meter in all plants. As a result, it was concluded that the forage plants used in the study have the potential to be used as a bee pasture, serving both as a roughage and as forage for bees. This approach may offer an alternative to reduce or eliminate itinerant beekeeping. Additionally, the use of these plants as a honeybee pasture in Bingöl and similar ecological conditions would be beneficial for both productivity and producers. However, as this is one of the first studies on bee pasture, further research is recommended.

Field Crops

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Bazı Baklagil Yem Bitkilerinin Arı Merası Olarak Kullanılma Potansiyelinin Belirlenmesi

ÖZET

Bu çalışma, tarımı yapılan bazı baklagil yem bitkilerinin arı merası olarak kullanılma potansiyellerinin incelenmesi amacıyla yürütülmüştür. Materyal olarak Macar fiği (*Vicia pannonica Crantz*), korunga (*Onobrychis viciifolia* Scop.) ve ak üçgül (*Trifolium repens* L.) bitkileri kullanılmıştır. Çalışma, Bingöl ekolojik koşullarında 2020/2021 ve 2021/2022 yetiştirme sezonunda yürütülmüştür. Çalışmanın birinci yılında ilk arı ziyaretine açılan bitki Macar fiği olurken, korunga ve ak üçgül birbirlerine yakın zamanlarda arı ziyaretine açılmıştır. İkinci yılda ise korunga ilk arı ziyaretine açılan bitki olurken, Macar fiği ve ak üçgül yakın tarihlerde arı ziyaretine açılmıştır. İki yıllık ortalamalara bakıldığında; ak üçgül 54 gün, korunga 34 gün ve Macar fiği 16 gün arı ziyaretine açık kalmıştır. Her iki yılın ortalaması bakımından bal arısı ziyaret sayısının Macar fiğinde 19.9 adet, korungada 36.35 adet, ak üçgülde ise 39.65 adet olarak elde edilmiştir. Çalışmada kullanılan her üç yem bitkisinin de 2021 ve 2022 yıllarında arı sayısı, arının çiçekte

Tarla Bitkileri

Araştırma Makkalesi

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Korunga
Ak üçgül

kalma süresi ve m²'deki çiçek sayısı açısından görülen farklılıkların istatistiksel olarak önemli olduğu tespit edilmiştir. 2021 yılında ise bitki boyu istatistiksel olarak önemsiz olarak elde edilmiştir. İki yıllık ortalama korelasyon verileri bakımından tüm bitkilerde; arı sayısı, arının çiçekte kalma süresi ve metrekaredeki çiçek sayısı arasında pozitif ilişkiler olduğu tespit edilmiştir. Sonuç olarak, çalışmada kullanılan yem bitkilerinin arı merası olarak kullanılma potansiyeline sahip olduğu, bitkilerden hem kaba yem kaynağı hem de arı merası olarak yararlanılabileceği, gezginci arıcılığı azaltmaya veya tamamen ortadan kaldırmaya yönelik kullanılacak alternatif bir yöntem olduğu, Bingöl ili ve benzer ekolojik koşullarda bu bitkilerin bal arısı merası olarak kullanılmasının ürün ve üretici açısından avantajlı olacağı sonucuna varılmıştır. Ancak bu çalışma arı merası ile ilgili yapılan ilk çalışmalardan biri olduğu için konuyla ilgili daha fazla araştırmanın yapılması gereklidir.

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INTRODUCTION

Given the changes in human population, soil conditions, and climate conditions, it has become increasingly important for agricultural production to serve multiple purposes. Based on this idea, identify alternative methods for cultivated legume forage crops that are highly valuable. Sainfoin (*Onobrychis viciifolia*), Hungarian vetch (*Vicia pannonica*), and white clover (*Trifolium repens*) are not only important forage crops but also important for beekeeping. These plants, grown primarily for forage production, can also support beekeeping during their flowering period. Thus, it is possible to generate both forage yield and seasonal benefits for apiculture (Çaçan et al., 2023; Kutlu et al., 2022; Özdemir et al., 2022). Even if the main purpose is a bee pasture, a significant amount of forage can still be harvested after flowering ends. These plants can be used as early spring nectar and pollen sources when natural vegetation is sparse and irregular, or flowering can be extended across the season through staggered planting times. Such practices may significantly reduce or even eliminate the need for itinerant beekeeping. Hungarian vetch is a forage crop native to Central Europe, naturally found in Anatolia, the Caucasus, the Mediterranean basin, and Europe (Balabanlı et al., 2009). It is commonly seen and widely cultivated in these regions (Koç et al., 2012; Uçar et al., 2022). Yields of 3-4 tons of green herbage and 7500-10000 kg/ha of dry matter have been reported (Sadık, 2011). In Turkey, sainfoin is one of the important legume forage crops widely used in both meadow-pasture and cultivated areas. It is a perennial forage crop tolerant to poor soil conditions (Açıkgöz, 2001; Dumanoğlu et al., 2021), rich in protein and minerals, and produces 4000-9000 kg/ha of biological yield under dry and irrigated conditions (Özdemir et al., 2023). White clover is a perennial legume forage plant native to Anatolia and Europe, generally adapted to warm and humid weather climates, and yields 5000-6000 kg/ha of dry matter (Açıkgöz, 2001; Ek et al., 2021). Besides its use in cultural agriculture, it is widely found in natural vegetation (Demirkol & Yılmaz, 2018). It has been reported that the highest number of bee visits was made to phacelia and sainfoin plants, respectively. Bees carried the most sainfoin pollen to the hive; the most flowers were obtained from sainfoin in a one square meter area, and bees visited the plant flowers between June 7-14 in Ordu ecological conditions (Kuvancı, 2009). In another study, sainfoin was found to flower for 33 days, and pollination by bees and insects was effective in seed set (Merve, 2010). Furthermore, a separate study on bee grass and Alexandrian clover reported that both plant species bloomed for about a month, bee visits were lowest at the beginning and end of flowering, while phacelia attracted the most bees (Kuvancı et al., 2016). Çankaya & Kumova (2018) described the effect of rapeseed on bee colony development and reported that the plant made significant contributions to colony development, especially in early spring. Under Malatya ecological conditions, honeybees were found to be the most effective insect species in fertilizing cherry flowers without any isolation (Çöçen et al., 2020). Honeybees are known to perform cost-benefit calculations when foraging, preferring the closer resource over distant ones (Couvillon et al., 2014). Meadow pasture areas and cultivated local plants are very important in the nutrition of bees (Srinu et al., 2023). It was reported that honeybees fed on *Alexandrian clover* production areas and increased plant seed production by 40% (Tufail et al., 2024). Schlager et al. (2024) described that honeybees are important in pollination and agricultural production. The abundance and diversity of honeybees are directly proportional to the presence of surrounding grasslands, agricultural production areas, forest areas, and wetlands

(Danner et al., 2016; Evans et al., 2018; Riedinger et al., 2015; Vickruck et al., 2019).

This study was conducted to determine the potential of Hungarian vetch, sainfoin, and white clover, which are important forage crops, for use as bee pasture. Additionally, it aimed to contribute to agricultural sustainability by revealing alternative uses for these crops beyond their conventional purpose.

MATERIAL and METHODS

Material

Sainfoin, Hungarian vetch, and white clover plant species were used as plant material in the study. Sainfoin and Hungarian vetch have racemose flower structures, while white clover has a clustered flower structure. While sainfoin and white clover are cross-pollinated, Hungarian vetch is self-pollinated. Only the honeybee was used in the study. Ten beehives were placed at a distance of 50-150 m from (bird's eye view) from the pasture area, with at least 5 frames of bees in each hive. This study was conducted at 38° 48' 41,7" N and 40° 32' 25.7". The study was carried out over two growing seasons of 2020/2021-2021/2022, at Bingöl University Agricultural Application and Research Center. The average altitude of the study site is around 1080 meters. The climatic data of the study area for 2020/2021, 2021/2022, and the long-term average are given in Table 1.

Table 1. Climatic data of the study area for 2020/2021, 2021/2022, and long-term (1961-2022) average (MGM, 2023)
Çizelge 1. Çalışma alanının 2020/2021, 2021/2022 ve uzun yıllar (1961-2022) ortalamasına ait iklim verileri (MGM, 2023)

	Average Temperature (⁰ °C)			Total Precipitation (mm)			Average Relative Humidity (%)		
Months	**2020-21**	**2021-22**	**1961-22**	**2020-21**	**2021-22**	**1961-22**	**2020-21**	**2021-22**	**1961-22**
October	17.1	14.8	14.5	0.0	72.6	69.0	36.3	41.8	56.4
November	8.5	9.4	6.8	56.2	67.2	94.7	59.7	66.5	65.2
December	3.1	1.4	0.7	43.0	109.1	131.1	72.0	72.5	73.1
January	-1.1	-2.2	-2.2	185.0	191.5	136.5	69.3	75.4	72.8
February	4.0	1.8	-0.9	56.2	82.4	131.0	60.2	71.9	71.0
March	6.1	1.9	4.7	133.9	259.7	131.3	62.4	71.1	65.2
April	14.3	13.9	10.9	22.5	50.7	110.1	50.2	45.2	61.1
May	20.4	15.1	16.2	3.3	99.0	80.6	33.3	56.2	56.9
June	24.4	23.0	22.2	1.8	22.0	21.1	30.2	40.3	44.3
July	28.4	27.0	26.7	0.2	0	6.9	28.6	29.2	37.2
August	27.3	27.8	26.7	3.9	0	4.9	31.0	26.4	36.0
September	21.3	22.5	21.3	12.7	5.3	14.8	36.1	30.9	41.3
Mean/Total	**14.4**	**13.03**	**12.3**	**518.7**	**959.5**	**932.0**	**47.4**	**52.2**	**56.7**

It was observed that the average temperature values of the first year were higher than both the second year and the long-term average, and both study years were warmer overall. According to the average total precipitation amount, it was observed that the second year of the study received more precipitation than both the first year and the long-term average, whereas the precipitation amount in the first study year was lower than the long-term average. In terms of the average relative humidity, the average temperature values showed that 2021 was warmer than both 2022 and the long-term average. In terms of total precipitation, 2021 had the lowest value and was significantly below the long-term average, while 2022 was above the long-term average—mainly due to high precipitation in March. In terms of average relative humidity, both study years were below the long-term average, with 2022 having a higher value than 2021.

Soil samples were taken from six different points in each plot after removing the top 20 cm of soil in the first year of the study, then mixed and analyzed as a single sample in the laboratory of the Department of Soil Science and Plant Nutrition, Faculty of Agriculture, Bingöl University. According to the results of the analysis, the soil was found to be slightly acidic in pH, free of salt content, low in organic matter content, sufficient in P_2O_5 and K_2O, and low in lime content.

Method

This study was conducted with three legume forage crops, white clover and sainfoin (perennial), and Hungarian vetch (annual). Seeds were used at the rate of 120 kg/ha for sainfoin, 20 kg/ha for white clover, and 100 kg/ha for Hungarian vetch, and all plants were sown at 40 cm row spacing. The first-year sowing of the annual Hungarian vetch was carried out on 02.10.2020, and the second-year sowing was on 30.09.2021. Perennial sainfoin and white clover plants were sown on June 3, 2020. DAP (Diammonium phosphate) fertilizer was applied to each plot with

the calculation of 40 kg/ha pure nitrogen and 80 kg/ha pure P2O5. A sprinkler irrigation system was used immediately after sowing to ensure homogeneous emergence. In the following periods, plants were irrigated as needed using a drip irrigation system. For each plant species, 33 m x 33 m plots were used, with 1.5 meters of spacing left between each plot. All observations and measurements were physically taken by the researcher. Honeybee traits were counted in three replicates in the morning (8.00-9.00), noon (12.00-13.00), and afternoon (15.00-16.00), and then averaged per day. Plant characteristics (plant height, number of flowers per square meter) were measured once per measurement day between 10.00 and 12.00 with three replicates. One square meter area determinant: It was obtained by joining three one-meter wooden slats into a rectangular frame with one open end. This tool was used in all measurements. The area marker was placed on a random surface in the parcel, and observations and measurements were taken from the area within the rectangle. The first flowering date was recorded for each plant plot. Following the flowering, the researcher checked the plot (33x33 m2) every day and determined the first day of bee visits. Once the first visit was made, measurements were taken every three days. All observations from the plots (33x33 square meters) were obtained from one square meter areas that were randomly selected before the measurements began. In each counting period, nine samples were used for the number of bees and the time bees spent on the flower, 15 for plant height, and 3 for the number of flowers per square meter. Number of bees: This refers to the total number of honeybees visiting the flowers in a 1 square meter area for 5 minutes. It represents the moment when any honeybee lands on a flower and then departs. If a bee leaves a flower and returns to it, or if a different bee lands on the same flower, both instances are counted as separate bee visits. Bees' time spent on the flower: This refers to the amount of time any bee spends on a particular flower, measured in seconds. Plant height was obtained by measuring the height of 10 randomly selected plants in a square meter area. The number of flowers per square meter was obtained by counting all the flowers blooming in a square meter area. Biological yield was measured once during the 50% flowering period in both 2021 and 2022 (Çaçan et al., 2022a; Çaçan et al., 2022b; Kuvancı & Deveci, 2010; Özyiğit & Bilgen, 2003).

Statistical Analysis

Tukey's HSD test was used to reduce the possibility of falsely detecting significant differences between years due to the homogeneous sample distribution. To determine the direction of the significant relationships in the two-year averages, a collinearity test was applied. This study followed a randomized block design with three replications. Analysis of variance was performed using the JMP statistical package. Differences within and between years for each trait were examined using Tukey's HSD test at 0.05% and 0.01% significance levels. Correlation analysis for the trait across the two years was conducted using the Spearman test in JMP (JMP, 2018).

RESULTS and DISCUSSION

Bee plant relationship

The first and last count dates shown in Table 2 represent the periods during which honeybees actively visited the plots and observations were taken. It was observed that the first flowering dates of the plant plots occurred approximately 5-10 days earlier than indicated in Table 2, and similarly, the end of flowering dates differ by the same time period. The reasons why observations could not be conducted during the first and final stages of flowering include factors such as honeybees' preference for alternative flowers in nature, an insufficient number of blooming flowers within the plot, scattered flower distribution, open flowers being outside the measurement area, or a noticeable decline in bee visitation during the late flowering period. In the second year of the study, the flowering period of the pasture plants was delayed due to the long winter season, the intensity of the rainfall in the last period of the spring season, and its long periodic duration. White clover had the longest total number of flowering days, followed by sainfoin and Hungarian vetch, both between years and in terms of the average of the two years.

The periods when legume forage crops were visited weekly by bees in 2021 and 2022 are given in Table 3. The colored areas in Table 3 are determined based on the first and last day of each month, with each month divided into four weeks. The purple colored areas represent the weeks during which the plants were visited by bees.

In the first year of the bee pasture study, bee visitation started with Hungarian vetch in the last week of April and continued continuously for 10 weeks until the first week of July with white clover. Although sainfoin flowered during the same period as white clover, bees intensively preferred sainfoin due to the limited flowering of white clover in the early stage. In 2022, bee visitation started with sainfoin in the second week of May and continued for 9 consecutive weeks until the second week of July with white clover. In 2021, the bee visitation period started in the 4th week of April, while in 2022 it shifted to the 2nd week of May. Similarly, in 2021, the visitation period ended in the first week of July, but in 2022 it extended to the 2nf week of July. In 2021, all three plants were simultaneously open to visitation during the first two weeks of May, whereas in 2022, all plants were open to

visitation during the last week of May and the first week of June. In the first year of the study, Hungarian vetch was the first plant to be visited by bees, while sainfoin was the first plant to be visited in the second year. In both years, white clover was the plant visited for the longest period, and its visitation ended last (Table 3).

Table 2. Total number of days honey bees visited plant flowers
Çizelge 2. Bal arılarının bitki çiçeklerini ziyaret ettiği toplam gün sayıları

Plants	2021			2022			Average
	First count date	Last count date	Total number of counted days	First count date	Last count date	Total number of counted days	
Hungarian vetch	23.04.2021	11.05.2021	18	20.05.2022	03.06.2022	14	16
Sainfoin	06.05.2021	10.06.2021	35	12.05.2022	13.06.2022	33	34
White clover	05.05.2021	01.07.2021	57	24.05.2022	14.07.2022	50	54

Table 3. Bee activity observed on plants by year (weeks)
Çizelge 3. Yıllara göre, bitkilerde gözlemlenen arı aktivitesi (haftalar)

Plants	April (Week)				May (Week)				June (Week)				July (Week)			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Year 2021																
Hungarian vetch																
Sainfoin																
White clover																
Year 2022																
Hungarian vetch																
Sainfoin																
White clover																

Evaluation of Hungarian vetch in terms of beekeeping

In 2021 and 2022, the number of honeybees visiting Hungarian vetch, the time bees spent on the flower, plant height, and number of flowers per square meter are given in Table 4. When Table 4 is examined; In the first year of the study, April 23 was statistically significant for all characteristics ($P \leq .01$- bees time spent on the flower ($q = .74$); $P \leq .05$ number of honeybees ($q = .97$), plant height ($q = .97$), number of flowers per square meter ($q = .90$). In 2022, it is seen that the differences seen in terms of the number of bees ($q = .99$), the bees time spent on the flower ($q = .93$) and number of flowers per square meter($q = .89$) are statistically significant at 5% level ($P \leq .05$), while the difference in plant heights ($q = .64$) was not significant (ns).

In 2021, the average number of bees was 14.8, the time bees spent on the flower was 9.9 seconds, plant height was 40.9 cm, and the number of flowers per square meter was 384. In 2022, the average number of bees was 25, the time bees spent on the flower was 6.3 seconds, plant height was 60.5 cm, and the number of flowers per square meter was 416. In 2021, bees visited the plant flowers most on May 4 and least on May 11. In the first year, bees spent the most time on May 7 and the least time on April 27. In 2021, the tallest plant height was obtained on April 30, and the shortest plant height was obtained on April 23. In the same year, the highest number of flowers per square meter was obtained on May 4, and the lowest on April 23. In 2022, bees visited the plant flowers most on May 27 and least on June 6. In the second year, bees spent the most time on June 27 and the least time on June 6. In 2022, there was no statistical difference between plant heights. In the same year, the highest number of flowers per square meter was obtained on May 27 and the lowest on June 6. In Hungarian vetch, May 11 (2021) and June 06 (2022) were the ending days of flowering. In 2022, due to the prolonged spring rainfall 2022, it was observed that Hungarian vetch bloomed about one month later than in 2021, bees preferred Hungarian vetch more in 2022 than in 2021, stayed on the flower of Hungarian vetch for a shorter time, the plant height was longer, and the number of flowers was higher (Table 4).

Considering the studies on Hungarian vetch, plant height was 52.3-63.1 cm under Diyarbakir conditions (Sayar et al., 2012), main stem length was 76-99 cm under Kırklareli conditions (Tenikecier et al., 2020), and plant height was 62-114 cm under Muş ecological conditions (Dağoğlu & Çaçan, 2022). On the other hand, Kutlu et al. (2022) reported that the number of bees was 14.9, the time bees spent on the flower was 9 seconds, the number of flowers per m^2 was 377 and the natural plant height was 38.7 cm, in Hungarian vetch while Gök and Çaçan (2023) reported that the plant height was 70.4 cm, the number of bees per m^2 was 12.4, the time bees spent on the flower was 9 seconds and the number of flowers per m^2 was 450. It is seen that these findings obtained previously by the researchers are similar to the findings of the present study in some points.

Table 4. Number of bees visiting hungarian vetch plots, bees time spent on the flower, plant height, and number of flowers per square meter

Çizelge 4. Macar fiği parsellerini ziyaret eden arı sayıları, arının çiçekte kalma süreleri, bitki boyları ve metrekarede çiçek sayıları

Year 2021				
Counting Time	**Number of Bees[1](pcs)**	**Bees time spent on the flower [1] (sec)**	**Plant height (cm)**	**Number of flowers per square meter (pcs)**
23.04.2021	4.7 c**	8.5 bc*	32.4 e**	51 d**
27.04.2021	12.4 b	7.1 c	35.8 d	184 cd
30.04.2021	17.0 b	10.0 bc	47.0 a	431 b
04.05.2021	36.2 a	10.7 ab	42.1 c	695 a
07.05.2021	15.4 b	14.2 a	44.5 b	676 a
11.05.2021	3.2 c	8.8 bc	43.3 bc	265 bc
Average	**14.8**	**9.9**	**40.9**	**384**
CV value	17.8	20	2.8	15.2
Year 2022				
20.05.2022	8.0 cd**	5.6 c**	63.7ns	572 ab**
24.05.2022	33.0 b	6.8 bc	58.5	626 ab
27.05.2022	92.2 a	11.1 a	60.5	755 a
31.05.2022	10.9 c	8.6 b	59.2	450 b
03.06.2022	4.7 cd	4.9 c	65.9	86 c
06.06.2022	1.0 d	1.0 d	55.3	7 c
Average	**25.0**	**6.3**	**60.5**	**416**
CV value	19.4	18.4	6.2	15.3

{*}, {**}: Significant at the P ≤.05 and P ≤.01 level of probability, ns: Not significant.

[1] Honeybees were counted in the morning, noon, and afternoon and converted into daily averages.

Evaluation of sainfoin in terms of beekeeping

In 2021 and 2022, the number of bees, the time bees spent on the flowers, plant height, and number of flowers per square meter were examined in sainfoin, as given in Table 5. Table 5 shows that the date on May 6 in the first year number, the number of bees (q = .98), the time bees spent on the flowers (q = .80), plant height (q = .91), number of flowers per square meter (q = .96) were statistically significant at the 1% level for all traits (P ≤ .01), and on May 12 in the second year, the number of bees (q = .79), the time bees spent on the flower (q = .78), plant height (q = .73), number of flowers per square meter (q = .80) were also statistically significant at the 1% level for all traits (P ≤.01).

In 2021, the average number of bees was 38.7, the time bees spent on the flowers was 7.6 seconds, plant height was 72.6 cm, and the number of flowers per square meter was 1748. In 2022, the average number of bees was 34, the time bees spent on the flower was 5.2 seconds, plant height was 79.5 cm, and the number of flowers per square meter was 1845. In 2021, it was determined that the maximum number of bee visits and the time bees spent on the flower occurred on May 24, the minimum on May 6. In 2021, the tallest plant height was recorded on June 3, and the shortest on May 6. In the same year, the maximum number of flowers per square meter was obtained on May 15, and the minimum on May 10. In 2022, the bees visited the plant flowers most on June 6 and least on May 12. In the first year, bees spent the most time in plant flowers on June 29 and the least time on May 12. In 2022, the tallest plant height was obtained on June 13, and the shortest plant height was obtained on May 12. In the same year, the highest number of flowers per square meter was obtained on May 31 and the lowest on June 13. In terms of the traits examined in sainfoin, the number of bees and the bees time spent on the flower gave higher values in the first year, while plant height and the number of flowers per square meter gave higher values in the second year. June 10 (2021) and June 13 (2022) were the ending days of flowering (Table 5).

In studies on sainfoin, plant height was 79.59 cm under Central Anatolian conditions (Ünal & Fırıncıoğlu, 2007), 29-98 cm in Antalya (Çeçen et al., 2015), 61.14 cm in Artvin (Temel & Özalp, 2016), 90.5-100.8 cm main stem length in Konya (Koç & Akdeniz, 2017), 60.84-11.46 cm main stem length in Eskişehir (Aygün et al., 2018), and 64.2 cm plant height in Bingöl (Özdemir et al., 2022). On the other hand, the number of flowers per plant in sainfoin was 12.33 and the number of bees per m2 was 10.33 (Özyiğit & Bilgen, 2003), the number of bees per m2 was 1.5 (Kuvancı & Deveci, 2010), the number of flowers per panicle was 12-38 (Çeçen et al., 2015), the number of flowers per square meter was 1303, the number of bees was 21.4, and the time bees spent on the flowers was 5.4 seconds (Özdemir et al., 2022). It is seen that these findings obtained previously by the researchers are similar to the findings of the present study in some points.

Table 5. Number of bees visiting sainfoin plots, time bees spent on the flower, plant height, and number of flowers per square meter

Çizelge 5. Korunga parsellerini ziyaret eden arı sayıları, arının çiçekte kalma süreleri, bitki boyları ve metrekarede çiçek sayıları

Year 2021				
Counting Time	**Number of Bees[1] (pcs)**	**Time Bees spent on the flower[1] (sec)**	**Plant height (cm)**	**Number of flowers per square meter(pcs)**
06.05.2021	1.0 g**	1.0 e**	49.4 e**	721 de**
10.05.2021	46.2 d	4.6 de	62.4 d	480 e
15.05.2021	43.2 de	7.8 bcd	72.8 c	5796 a
20.05.2021	56.0 c	11.1 ab	73.5 bc	2692 b
24.05.2021	99.8 a	12.1 a	78.5 abc	2313 b
27.05.2021	65.8 b	10.4 ab	79.5 ab	1582 c
31.05.2021	34.0 ef	8.3 bc	79.9 ab	1297 cd
03.06.2021	28.2 f	9.7 abc	80.5 a	1160 cd
07.06.2021	9.0 g	6.2 cd	75.0 abc	795 de
10.06.2021	4.2 g	4.3 de	74.2 abc	639 de
Average	**38.7**	**7.6**	**72.6**	**1748**
CV value	14.0	10.4	5.3	19.4
Year 2022				
12.05.2022	1.0 f**	1.0 d**	69.7 d**	299 e**
16.05.2022	7.7 ef	4.0 c	74.9 cd	499 de
19.05.2022	16.0 def	5.3 c	79.7 bc	723 cde
24.05.2022	40.4 bcd	4.8 c	75.9 bcd	2509 b
27.05.2022	71.1 ab	5.8 bc	73.8 cd	2006 bcd
05.31.2022	37.0 cde	5.3 c	74.9 cd	4212 a
06.03.2022	54.2 abc	7.9 ab	79.7 bc	4177 a
06.06.2022	77.0 a	5.4 c	84.9 ab	2174 bc
06.09.2022	34.7 cde	8.2 a	89.7 a	1587 be
13.06.2022	1.3 f	3.9 c	92.3 a	269 e
Average	**34.0**	**5.2**	**79.5**	**1845**
CV value	21.2	13.4	7.1	17.0

{*}, {**}: Significant at the P ≤.05 and P ≤.01 level of probability.

[1] Honeybees were counted in the morning, noon, and afternoon, and converted into daily averages.

Evaluation of white clover in terms of beekeeping

In 2021 and 2022, the number of bees, the time bees spent on the flowers, plant height, and the number of flower heads per square meter were examined in white clover, as given in Table 6. When Table 6 is examined, it is seen that the differences seen in terms of the number of bees (2021; q = .92- 2022; q = .97), the time bees spent on the flower (2021; q = .83- 2022; q = .96), plant height (2021; q = .97- 2022; q = .91) and the number of flower heads per square meter (2021; q = .91- 2022; q = .95) among the traits examined in 2021 and 2022 are statistically significant (P ≤.01).

In 2021, the average number of bees was 39.2, the time bees spent on the flower was 8.8 seconds, the plant height was 27.5 cm, and the number of flower heads per square meter was 92.9. In 2022, the average number of bees was 40.1, the time spent on the flower was 4.1 seconds, the plant height was 28 cm, and the number of flower heads per square meter was 92.1. In 2021, bees visited the plant flowers most on May 28 and last on July 1. In the first year, bees spent most time planting flowers on May 28 and the least on July 1. In 2021, the tallest plant height was obtained on June 21, and the shortest plant height was obtained on May 5. In the same year, the maximum number of flowers per square meter was obtained on June 4 and the minimum on May 5. In 2022, bees visited the plant flowers the most on June 30. In the second year, the time bees spent on flowers on May 27. In 2022, the longest plant height was obtained on July 4. In the same year, the highest number of flowers per square meter was obtained on June 30. In 2022, the lowest value for all traits was obtained on June 6. In white clover, July 01 for 2021 and July 14 for 2022 were the ending days of flowering (Table 6).

In studies on white clover, it was reported that the plant height of white clover in Eastern Anatolia pastures varied between 11.33 and 26.62 cm (Aygün & Olgun, 2014), and the plant height of white clover in Antalya conditions varied between 18-31 cm (Öten et al., 2019). It is seen that these findings obtained previously by the researchers are similar to the findings of the present study in some points.

Table 6. Number of bees visiting white clover plots, time bees spent on flower, plant height and number of flowers per square meter

Çizelge 6. Ak üçgül parsellerini ziyaret eden arı sayıları, arının çiçekte kalma süreleri, bitki boyları ve metrekarede çiçek sayıları

Year 2021				
Counting Time	**Number of Bees[1] (pcs)**	**Time Bees spent on flower[1] (sec)**	**Plant Height**	**Number of flower head per square meter (pcs)**
05.05.2021	14.2 fg**	9.9 bc**	15.5 d**	13.8 h**
10.05.2021	17.2 fg	9.6 bcd	16.5 d	33.8 gh
15.05.2021	36.5 de	10.8 bc	19.4 cd	65.0 d-h
21.05.2021	52.8 cd	10.1 bc	18.2 d	85.0 d-g
25.05.2021	45.0 d	9.4 bcd	23.3 bc	88.3 def
28.05.2021	111.7 a	23.9 a	25.6 b	146.3 abc
01.06.2021	65.0 c	12.5 b	30.9 a	165.0 ab
04.06.2021	89.3 b	10.5 bc	30.9 a	181.3 a
08.06.2021	36.8 de	7.6 cde	31.8 a	117.5 bcd
11.06.2021	65.7 c	7.0 cde	32.2 a	113.8 bcd
06.14.2021	26.5 ef	7.4 cde	31.8 a	108.8 cd
06.17.2021	18.3 fg	5.3 de	32.8 a	101.3 cde
21.06.2021	11.5 fg	4.8 e	34.3 a	93.8 cde
06.24.2021	12.3 fg	4.0 e	33.3 a	77.5 dg
06.28.2021	21.5 ef	4.6 e	32.2 a	55.0 eh
01.07.2021	3.3 g	3.5 e	31.9 a	40.0 fgh
Average	**39.2**	**8.8**	**27.5**	**92.9**
CV value	7.6	12.3	5.6	18.8
Year 2022				
24.05.2022	21.7 fg**	4.1 cd**	26.9 cf**	99.0 cd**
27.05.2022	106.4 b	9.8 a	23.6 d-g	109.7 bc
31.05.2022	50.0 cd	4.5 c	21.8 efg	126.3 bc
03.06.2022	3.0 hi	3.7 cde	20.7 fg	18.3 ef
06.06.2022	0.0 I	0.0 g	15.9 g	0.0 f
09.06.2022	20.6 fg	4.1 cd	21.7 efg	27.7 ef
13.06.2022	27.1 ef	4.5 c	21.5 efg	31.3 ef
16.06.2022	57.7 c	5.8 b	29.1 ae	81.0 cde
20.06.2022	53.3 cd	3.4 def	28.9 ae	126.3 bc
23.06.2022	51.1 cd	4.1 cd	36.1 ab	167.3 b
06.27.2022	41.7 de	6.4 b	36.7 a	135.3 bc
06.30.2022	160.8 a	3.3 def	36.5 a	242.3 a
04.07.2022	21.8 f	3.1 ef	36.8 a	238.0 a
07.07.2022	14.9 fgh	2.9 ef	28.1 bf	32.3 def
12.07.2022	4.8 hi	2.7 f	30.3 ad	25.0 ef
14.07.2022	7.0 ghi	2.9 ef	33.1 abc	14.3 ef
Average	**40.1**	**4.1**	**28.0**	**92.1**
CV value	15.3	13.5	9.4	15.1

{*}, {**}: Significant at the P ≤.05 and P ≤.01 level of probability.

[1] Honeybees were counted in the morning, noon, and afternoon, and converted into daily averages.

Two-year average values

The two-year averages of the number of bees, the time bees spent on the flower, plant height, the number of flowers per square meter, and the biological yields of the plants used in the study are given in Table 7.

When the two-year average values for the traits examined in Hungarian vetch were examined, the number of bees detected per m2 was 19.9, the time bees spent on the flowers was 8.1 seconds, the plant height was 50.7 cm, the number of flowers per m2 was 400, and the biological yield was 3130 kg/ha. For sainfoin, the two-year average values were 19.9, and the number of bees detected per m² was 36.4, the time bees spent on the flowers was 6.4 seconds, the plant height was 76 cm, the number of flowers per m² was 1797, and the biological yield was 9240 kg/ha. When the two-year average values of white clover were examined, the number of bees detected per m2 was 39.7, the time bees spent on the flower was 6.5 seconds, the plant height was 27.8 cm, the number of flowers per

square meter was 93, and the biological yield was 10790 /kg/ha. The most visited plant by bees was white clover with 39.7 bees per m2. The bees stayed in the flowers of Hungarian vetch for 8.1 seconds. In the bee pasture, the tallest plant height was obtained from sainfoin with 76.5 cm, and the shortest plant height was recorded for white clover with 27.8 cm. The highest number of flowers per m² was obtained for sainfoin with 1797. The highest biological yield was obtained from white clover, sainfoin, and Hungarian vetch, in that order.

Table 7. Two-year average values of the analyzed parameters
Çizelge 7. İncelenen parametrelerin iki yıllık ortalama değerleri

	Hungarian vetch	Sainfoin	White clover
Number of bees (pcs)	19.9	36.4	39.7
Time bees spent on the flower (sec)	8.1	6.4	6.5
Plant height (cm)	50.7	76.1	27.8
Number of flowers per square meter (pcs)	400	1797	93
Biological yield (kg/ha)	3130	9240	10790

The correlation relationships for the two-year number of bees, the time bees spent on the flower, plant height, and number of flowers per square meter parameters are given in Tables 8, 9, and 10.

Table 8. Two-year correlation coefficients of traits obtained from Hungarian vetch
Çizelge 8. Macar fiğinden elde edilen özeliklere ait iki yıllık korelasyon katsayıları

	Number of bees	Time Bees spent on the flower	Plant height	Number of flowers per square meter
Number of bees	1			
Bees time spent on the flower	0.429*	1		
Plant height	0.215	-0.369	1	
Number of flowers per square meter	0.672**	0.654*	0.225	1

{*}, {**}: Significant at the P ≤.05 and P ≤.01 level of probability.

Table 9. Two-year correlation coefficients of traits obtained from sainfoin
Çizelge 9. Korungadan elde edilen özeliklere ait iki yıllık korelasyon katsayıları

	Number of bees	Bees time spent on the flower	Plant height	Number of flowers per square meter
Number of bees	1			
Bees time spent on the flower	0.678**	1		
Plant height	0.197	0.421	1	
Number of flowers per square meter	0.496**	0.400**	0.071	1

{**}: Significant at the P ≤.01 level of probability.

Table 10. Two-year correlation coefficients of traits obtained from white clover
Çizelge 10. Korungadan elde edilen özeliklere ait iki yıllık korelasyon katsayıları

	Number of bees	Time Bees spent on flower	Plant height	Number of flowers per square meter
Number of bees	1			
Time bees spent on the flower	0.480**	1		
Plant height	0.172	-0.220	1	
Number of flowers per square meter	0.696**	0.231	0.574**	1

{**}: Significant at the P ≤.01 level of probability.

There is a strong positive correlation between the number of flowers per square meter and the number of bees, and it is statistically significant at 1% (r = 0.672). There is a statistically significant correlation between the time bees

spent on the flower, the number of bees (r = 0.429), and between the number of flowers per square meter and the bees time spent on the flower (r = 0.654) at P ≤.05. Also, there is a moderate positive correlation between the number of bees and the time bees spent on the flower. There is a weak positive correlation between plant height and the number of bees, the number of flowers per square meter, and plant height. In addition, there is a moderate negative correlation between plant height and the time bees spent on the flower. And there is a strong positive correlation between the number of flowers per square meter and the time bees spent on the flower.

The time bees spent on the flowers and number of bees (r = 0.678), number of flowers per square meter and number of bees (r = 0.496), the number of flowers per square meter and the time bees spent on the flowers (r = 0.400) were significantly correlated at the 1% level. There is a strong positive correlation between the time bees spent on the flower and the number of bees. There is a moderate positive correlation between plant height and the time bees spent on the flower, but it is not statistically significant. There is a weak positive correlation between plant height and the number of bees, but it is not statistically significant. There is a moderate positive correlation between the number of flowers per square meter and the number of bees, and between the number of flowers per square meter and the time bees spent on the flower. There is a weak positive correlation between the number of flowers per square meter and plant height.

A statistically significant correlation was found between the time bees spent on the flower and the number of bees (r =0.480), the number of flowers per square meter and the number of bees (r = 0.696), the number of flowers per square meter and plant height (r = 0.574) at 1% level. There is a moderate positive correlation between the number of bees and the time bees spent on the flower. There is a weak positive correlation between plant height and the time spent on the flower, and between plant height and the number of bees, but it is not statistically significant. There is a strong positive correlation between the number of flowers per square meter and the number of bees. There is a weak positive correlation between the number of flowers per square meter and the time bees spent on the flower. There is a moderate positive correlation between the number of flowers per square meter and plant height.

It is suggested that the average temperature in March of the first year, which was higher than the long-term average, and the total rainfall was similar to the long-term average, did not cause an extreme situation in plant development, and the high temperature encouraged honeybees to leave the hive. In the second year, March was cool and rainy, which had a positive effect on plant growth but decreased bee activity and delayed flowering. April was hot and dry in both years, which had a positive effect on bees leaving the hive but had a negative effect on plant development and the number of flowers. Regular maintenance and irrigation in other months prevented the occurrence of extreme conditions in plant development. The fact that the weather was generally above 15 0C in May and the following months did not prevent bee activity (Table 1).

In the correlation analysis results of the plants used in the study, it is determined that how frequently honeybees visit a plant and how long they stay on the flowers depend on the flower density per square meter. The abundance of flowers both attracts more bees and ensures their longer stay on the plant. However, the effect of plant height on the number of bees and the time bees spent on the flower was limited. These data reveal that flowering density is a critical criterion in the selection of plant species to be used as a bee pasture. The statistically significant and positive relationships between the number of bees, the time bees spent on the flower, and the number of flowers per square meter strengthen the potential of these plants to be evaluated as bee pastures. It is seen that this positive association direction affects the preferences of honeybees. It is seen that these statistical relationships provide clues about honeybee feeding behavior and form the basis for research in this regard. Flower abundance is a driving force in bee behavior, and plants with a high number of flowers are more likely to be visited by bees (Kunin, 1997; Pernal & Currie, 2002; Wisdom et al., 2024).

It is also thought that the flowers of the plants are not significantly affected by climatic conditions due to regular irrigation (drip irrigation) and maintenance work during the general development period of the plants. It constitutes a research standard in terms of bee-plant relationships.

The reasons why bees prefer the subjects of the research are thought to be due to their being the subject of previous research, the number of flowers of the plants, the flowering periods, the number of flowers in the area, and the amount of nectar.

The graphical distribution of the parameters of flowering time of plants, plant height, number of flowers, biological yield, number of bees, and the time bees spent on the flower according to 2021, 2022, and two-year averages is given in Figure 1.

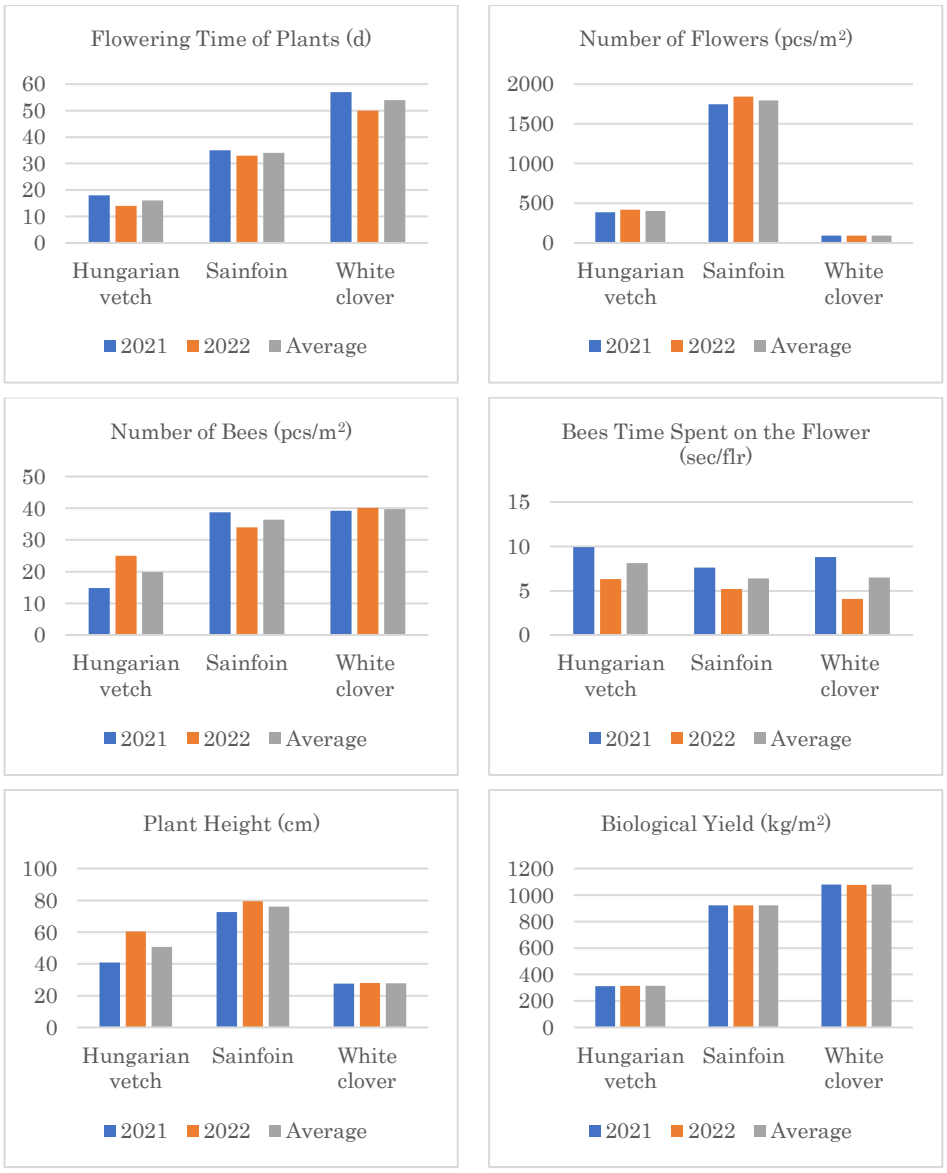

Figure 1. Graphical distribution of observed parameters
Şekil 1. Gözlemlenen parametrelerin grafiksel dağılımı

According to the average data of two years, white clover provided higher values than sainfoin and Hungarian vetch in terms of total number of visiting days, biological yield, and number of bees visiting flowers. According to the average data of two years, sainfoin provided higher values than other plants in terms of plant height and number of flowers. According to the average data of two years, Hungarian vetch provided higher values than other plants in terms of the time bees spent on the flowers (Figure 1).

Considering the prominent features of white clover compared to other plants, it is seen that it is both an important bee plant and an important forage plant. Therefore, it is obvious that the remaining parts of white clover after it is used as a bee pasture can be easily fed to animals, and in this way, economic income can be obtained from both beekeeping and animal feed. The high number of flowers and the gradual flowering of the corunga provide abundant flowers per unit area, and it is predicted that the number of bees will increase as the cultivation area increases. The fact that bees spend a long time in Hungarian vetch may be due to the amount of nectar, pollen, and flower structure of the plant.

CONCLUSIONS

According to the two-year data, it was determined that there were strong positive relationships between the number of flowers per square meter, the number of bees, and the time bees spent on the flowers for all plants. Hungarian vetch, sainfoin, and white clover are excellent forage crops and have the potential to be good bee pasture

plants. Even if these plants are planted for forage production, they have the potential to be used as a bee pasture during the flowering period. When Hungarian vetch, sainfoin, and white clover plants are planted for bee pasture, they have the potential to be harvested at the end of the flowering period and used as a roughage source. It was found that these plants are visited by honeybees in significant numbers, and that honeybees accept these plant flowers as feeding ones at any given time. It is foreseen that in certain quantities and periods; forage production and beekeeping can be done together, this will not have any negativity in terms of public health, on the contrary, in periods when flowers are limited in nature, the feeding of bees with sugar, antibiotics and artificial nutrients will decrease, and this will contribute to the protection of both bee health and bee products.

As a result of this study, it was determined that in Bingöl province and similar ecological conditions, these forage plants provide flowers of sufficient quality and abundance to attract honeybees from April to July. These plants can be used as effective bee pasture during these periods, and after the flowering phase ends or within a determined timeframe, the remaining biomass can be utilized to meet the roughage needs of livestock. Similar to the ecological conditions of Bingöl, the cultivation of these forage crop species is also carried out in various ecological regions of our country. In various parts of our country, bee pastures can be established using plant species and varieties adapted to those localities, thereby contributing to sustainability in agricultural production. Since this study is one of the first ones, it should be further expanded through scientific research under different conditions, including diverse varieties, plant species, sowing times, maintenance practices, and ecological settings.

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Author Contribution

The authors contributed equally.

Conflict of Interest

The authors of the article declare that there is no conflict of interest between them.

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