How to cite: Uçar, R., K. Kökten & E. Çaçan, 2025. Evaluation of selected medicinal and aromatic plants for use as bee pasture under the ecological conditions of Bingöl. Ege Univ. Ziraat Fak. Derg., 62 (3): 391-406, https://doi.org/10.20289/zfdergi.1615673

Research Article
(Araştırma Makalesi)

Rıdvan UÇAR[1*]

Kağan KÖKTEN[2]

Erdal ÇAÇAN[3]

[1*]Department of Field Crops Faculty of Agriculture Pamukkale University Denizli, Türkiye

[2] Department of Plant Production and Technologies - Faculty of Agricultural Sciences and Technology Sivas University of Science and Technology Sivas, Türkiye

[3] Bingöl University, Vocational School of Food, Agriculture and Livestock, Department of Crop and Animal Production, Bingöl, Türkiye

*Corresponding author (Sorumlu yazar): 12ridvanucar@gmail.com

Keywords: Basil, bee plant relationship, honeybee, lavender, thyme

Anahtar sözcükler: Fesleğen, arı bitki ilişkisi, bal arısı, lavanta, kekik

Ege Üniv. Ziraat Fak. Derg., 2025, 62 (3):391-406
https://doi.org/10.20289/zfdergi.1615673

Evaluation of selected medicinal and aromatic plants for use as bee pasture under the ecological conditions of Bingöl*

Bingöl ekolojik koşullarında arı merası olarak kullanılabilecek seçilmiş tıbbi ve aromatik bitkilerin değerlendirilmesi

* This article is derived from the first author's PhD thesis. The authors are grateful for financial support.

Received (Alınış): **08.01.2025** **Accepted** (Kabul Tarihi):**26.08.2025**

ABSTRACT

Objective: Use of some cultivated medicinal and aromatic plants as bee pasture to examine their potential.

Materials and methods: The study was conducted using lavender (*Lavandula officinalis*), basil (*Ocimum basilicum*), thyme (*Satureja hortensis*) plants and honeybee colonies in the 2020/2021 and 2021/2022 growing seasons.

Results: In both years of the study, lavender was the first plant to be visited by bees. According to the two-year averages, basil was open to bee visits for 58 days, thyme for 38 days and lavender for 30 days. The average number of honeybee visits was 63.9 in lavender, 55.75 in thyme, and 12.2 in basil. Bees spent the most time in lavender flowers and the least time in thyme flowers. In terms of years and plants, all characteristics of thyme were statistically significant except the number of plants per square meter in 2021 and the number of flowers per stem in lavender in 2022.

Conclusion: It was concluded that these plants can be used directly or indirectly as bee pasture in Bingöl province and similar ecological conditions. Since this study is one of the first to explore this subject, alternative plants, conditions, and methods need to be further investigated.

ÖZ

Amaç: Tarımı yapılan bazı tıbbi ve aromatik bitkilerin arı merası olarak kullanılma potansiyellerinin incelenmesi amacıyla yürütülmüştür.

Materyal ve Yöntem: Çalışma 2020/2021 ve 2021/2022 yetiştirme sezonunda lavanta (*Lavandula officinalis*), fesleğen (*Ocimum basilicum*), kekik (*Satureja hortensis*) bitkileri ve bal arısı kolonileri kullanılarak yürütülmüştür.

Tartışma Bulguları: Çalışmanın her iki yılında da lavanta ilk arı ziyaretine açılan bitki olmuştur. İki yıllık ortalamalara göre; fesleğen 58 gün, kekik 38 gün ve lavanta 30 gün arı ziyaretine açık kalmışlardır. Bal arısı ortalama ziyaret sayısının lavantada 63.9 adet, kekikte 55.75 adet fesleğende ise 12.2 adet olarak elde edilmiştir. Arılar en fazla süreyi lavanta çiçeğinde geçirirken, en az süreyi kekik çiçeğinde geçirmiştir. Yıllar ve bitkiler özelinde: kekik bitkisinin 2021 yılı metrekaredeki bitki sayısı ve lavantanın 2022 yılı sap başına çiçek sayısı parametreleri dışında kalan tüm özelikleri istatistiki açıdan önemli bulunmuştur.

Sonuç: Bu bitkilerin Bingöl ili ve benzer ekolojik koşullarda direk ya da dolaylı olarak arı merası olarak kullanılmasının mümkün olduğu sonucuna varılmıştır. Bu çalışmanın konu ile ilgili yapılan ilk çalışmalardan olması nedeni ile alternatif bitkiler, koşullar ve yöntemler ile daha fazla araştırılmaya ihtiyacı bulunmaktadır.

INTRODUCTION

It is a general belief that the increasing human population and climate change adversely affect areas such as water, soil, vegetation, other living species, natural habitats, and agricultural lands and that shortages in these areas will lead to wars in the coming years. On the other hand, in the event of the emergence of dangerous epidemics, when country borders are closed, and trade is restricted, human nutrition on a micro and macro scale will be in difficulty. It is very important to ensure high yields from agricultural areas and to utilize them for multiple purposes simultaneously, to consider the secondary uses of agricultural plants beyond their primary purposes, and to incorporate their wastes into the utilization cycle. Plant and animal foods are fundamental sources affecting human health and quality. These foods are obtained from the joint work of plant production areas and animal breeding disciplines. Plant production is recognized as the starting point of this cycle. In addition to basic cultivation techniques, it is important to utilize medicinal and aromatic plants as pasture for bees. When crops are harvested towards the end of the flowering period, it is possible to provide bee colonies with a significant amount of nectar and pollen. Thus, with the help of artificial pastures, bee colonies can be strengthened, and extra income can be generated from bee products. Establishing a bee pasture contributes to the conservation of biodiversity, ensures the production of more and higher-quality products compared to conventional agriculture. It has been reported that some plants need bees for pollination. Some of the cultivated plants are completely pollinated by bees, while others are pollinated by bees at certain rates. Bees can be used in cultural agriculture areas because they can be easily controlled by humans and have high adaptability to climatic conditions (Sıralı & Cınbırtoğlu, 2018). The production of materials related to beekeeping and the products obtained (honey, pollen, royal jelly, propolis, bee venom, etc.) is becoming an important branch of agricultural activity every day (Şahin & Gök, 2004). It is very important to have a thorough understanding of the plant flora in the areas where beekeeping is practiced, including the flowering periods, the beginning, duration, and amount of nectar flow (Genç, 1990). In addition to honey production, beekeeping plays a role in the pollination of medicinal and cultivated plants (Jadran, 2011). With the inability to maintain natural pollinator populations in agricultural production areas, continuous management of pollinators is necessary (Durant, 2021). In agricultural areas, honeybees and other pollinators can increase crop quantity and sustainability (Greenleaf & Kremen, 2006; Brittain et al., 2013; Garibaldi et al., 2013). It has been reported that increasing agricultural areas does not negatively affect the amount of pollen or the number of bees (Ritchie et al. 2020).

This study aims to determine the relationship between the parameters studied and honeybees, and to create, at certain times, a feeding area for honeybees. The objective of this study is to reveal the potential of using agricultural product production areas as bee pasture both in our province and in our country.

MATERIALS and METHODS

Material

Lavender (*Lavandula angustifolia*), thyme (*Thymus vulgaris*), and basil (*Ocimum basilicum*) plant species were used as plant material in the study. All plants are mostly cross-fertilized. Only the honeybee (*Apis mellifera* L.) was used in the study. Ten beehives were placed to cover a distance of 50-150 m range within the pasture area, with at least five frames of bees in each hive. This survey, 38° 48' 41.7" N and 40° 32' 25.7"E. The study was conducted for two years in the growing season of 2020/2021, 2021/2022 in the area at Bingöl University Agricultural Application and Research Center, which is located in position E. The height of the study area above sea level is around 1080 meters. The climatic data of the study area for 2020/2021, 2021/2022, and long-term average are given in Table 1.

It was determined that the average temperature values in the first year of the study were higher than both the long-term average and the value of the second year, and the long-term average temperature was lower than the values obtained in both years. In terms of total precipitation, it was

determined that the second year had higher precipitation than the first year, while the average precipitation during the first year was much lower. The average relative humidity was below the long-term average in both study years. In the first year, the month with the highest difference between the average temperature values and the long-term average temperature values was February, and the month with no difference was September. In the second year, the highest difference occurred in June, while the month with no change was April. In terms of total rainfall in the first year, the highest difference was obtained in April and the lowest difference in November. In the second year, the highest difference total rainfall was observed in March and the least difference was observed in June. In terms of percent relative humidity in the first year, the highest change was obtained in January, while March showed no difference. In the second year, the highest change in relative humidity percentage was obtained in July, while the month with no difference was March. Regular irrigation and maintenance of the plants used in the study prevented the occurrence of extreme conditions in cultivation. It is thought that the temperature values being similar to the long-term averages and the absence of rainy and overcast weather did not affect the bee activity (Table 1).

Table 1. Climate data for 2020/2021, 2021/2022 and long-term averages (MGM, 2023)

Çizelge 1. *2020/2021, 2021/2022 ve uzun yıllar ortalamalarına ait iklim verileri (MGM, 2023)*

Months	Average temperature (0C)			Total precipitation (mm)			Average relative humidity (%)		
	2020-2021	2021-2022	Long Years	2020-2021	2021-2022	Long Years	2020-2021	2021-2022	Long Years
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
Marc	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
Av./Total	**14.4**	**13.03**	**12.3**	**518.7**	**959.5**	**932.0**	**47.4**	**52.2**	**56.7**

Soil samples were taken for each plot from 6 different points after cleaning the first 20 cm of the soil in the first year of the study. The samples were 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, pH was found to be slightly acidic, salt-free, low in organic matter and lime content, and adequate in P_2O_5 and K_2O content.

According to the soil analysis results, the low salt content, slightly acidic pH, and adequate potassium levels are advantageous for the growth of the selected plant species and fall within their tolerance ranges. Although the low level of organic matter is considered a disadvantage for plant cultivation, this condition has been compensated for through fertilization practices. Overall, the climatic and soil conditions were found to be within acceptable limits for the normal growth and development of the plant species used in the study.

Methods

This study was conducted with three medicinal and aromatic plants, one perennial and two annual plants. For each plant species, 33 m x 33 m plots were used, and 1.5 meters of road was left between the

plots. Lavender 1562 g/ha, thyme 1000 g/ha, and basil 3125 g/ha were used as seeds. Lavender was sown at a row spacing of 80 cm, and thyme and basil at a row spacing of 40 cm. DAP fertilizer was applied to each plot with 8 kg N and 8 kg P for lavender, thyme and basil plants (Atalay, 2008; Sotiropoulou & Karamanos, 2010; Büyükbayraktar, 2014; Yeşil & Kara, 2015; İşcan, 2018). Lavender was planted on June 18, 2020, first year thyme on May 08, 2021, and basil on May 22, 2021, and second year thyme and basil on May 09, 2022. The sprinkler irrigation system was used immediately after sowing and planting, to ensure a homogeneous emergence, while in the following periods, the plants were irrigated with the drip irrigation system as needed. All observations and measurements were taken by the researcher. Honeybee traits were measured in three replicates in the morning (8-9), noon (12-13), afternoon (15-16), and converted to daily averages. Plant traits (plant height, number of flowers per square meter) were measured once in three replicates between 10:00 and 12:00 on each measurement day. One square meter area determinant: It was obtained by joining three wooden slats of one meter length, into a rectangle open at one end. This tool was used in all measurements. The area marker was placed on a random surface in the plot and observations and measurements were taken from the area inside the rectangle. The date of first flowering was tracked for each plant plot. After flowering started, the plot (33 x 33 square meters) was checked daily by the researcher to determine the first day of honeybee visits. After the first bee visit was determined, measurements were taken every three days. All observations in the plots (33x33 square meters) were obtained from randomly selected 1-square-meter areas, before the measurements started. Number of bees: This refers to the total number of honeybees visiting flowers in a per 1 square meter area for 5 minutes. It represents the moment at which any honeybee lands on a flower then leaves. If a bee leaves a flower and returns, or if a different bee lands on the same flower, both cases are counted as separate bee visits. Bee visit duration: this refers to the time spent by any one bee on a particular flower, measured in seconds. The average plant height was obtained by measuring ten randomly selected plants in one square meter. The number of flowers per square meter was obtained by counting all flowers blooming on one square meter (Özyiğit & Bilgen, 2003; Kuvancı & Deveci, 2010; Çaçan et al., 2022a, b; Gök & Çaçan, 2023).

This study was carried out using a randomized block design with three replications. Analysis of variance was applied to the data, obtained using the JMP statistical package program. Within-year differences for each trait examined in the experiment were determined by Tukey test at 0.05 and 0.01 levels. Correlation analysis was performed with Spearman's test (0.05% and 0.01%), in JMP to determine the relationship between the characters examined for two years (JMP, 2018).

RESULTS and DISCUSSION

Studies carried out within the scope of bee-plant relationship The beginning of bee visitation, the end of bee visitation and the average number of days of bee visitation for 2021, 2022 and the averages of the plants planted within the scope of the study are given in Table 2.

Table 2. Total number of days honeybees visited plant flowers (2021, 2022 and average)

Çizelge 2. *Bal arılarının bitki çiçeklerini ziyaret ettiği toplam gün sayıları (2021, 2022 ve ortalama)*

Plants	Bee visit start	End of bee visit	2021	Bee visit start	End of bee visit	2022	Average number of bee visit days
Lavender	07.06.2021	01.07.2021	24	13.06.2022	18.07.2022	35	**30**
Thyme	11.08.2021	23.09.2021	43	05.09.2022	06.10.2022	32	**38**
Basil	11.08.2021	23.09.2021	43	28.07.2022	06.10.2022	72	**58**

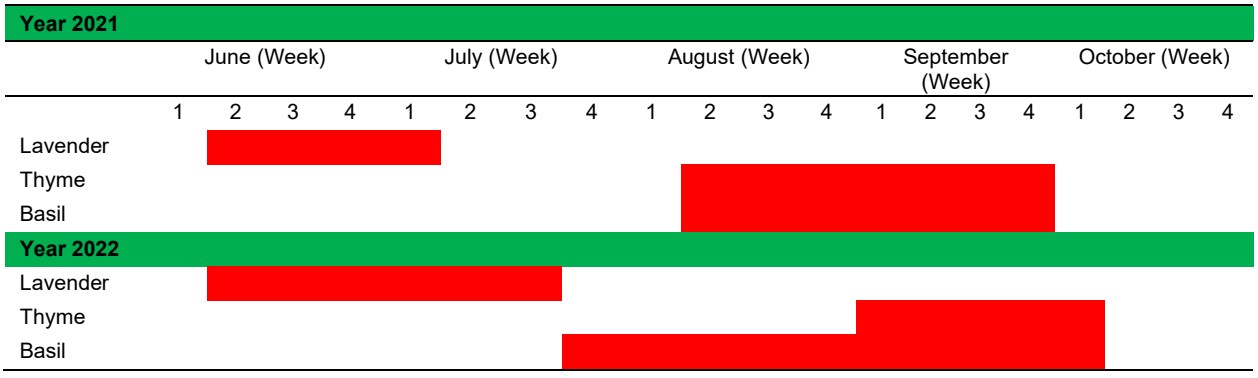
Bee visit start and bee visit end dates refer to the periods when honey bees actively visited the plots and the researcher made observations. In general, the dates of the first bee visit and the last bee visit are 5-10 days different from those given in Table 2. Factors thought to be effective include

honeybees turning to alternative flowers in nature during the first and last period of flowering, an insufficient number of flowers blooming in the plot, scattered blooming flowers, open flowers being outside the measurement area, or the relative continuation of bee spread in the plot during the last period of flowering. In the first year, the bee visit start and end dates of thyme and basil plants, which were sown and planted in the same week, were on the same days, while in the second year, basil opened for bee visitation about 38 days before thyme and ended on the same day. Another reason why the measurements of the two plants ended on the same days is that the plants were stressed due to the onset of night cold and the temperatures during the day were not sufficient for bee visitation. In both years and in terms of average value, basil, was the plant that was open to bee visitation for the longest time, followed by thyme and lavender in the first year, and lavender and thyme in the second year. Based on the two-year average, basil was the plant open to bee visitation for the longest time, followed by thyme and lavender. The reason basil remains open to bee visits more than other plants is that the flowering of the plant occurs at different times and is renewed by irrigation. However, in thyme and lavender, flowering occurs at a consistent time and does not change depending on irrigation.

The weekly periods when the plants used in the bee pasture were open to bee visits in 2021 and 2022 are given in Table 3.

Table 3. Period of bee activity observed in plants by year (Weeks)

Çizelge 3. *Yıllara göre bitkilerde gözlenen arı aktivitesi periodu (Hafta)*



In the first year of the study, bee visitation to lavender started on the first day of the second week of June and continued until the first week of July. No flowering plants were found from the second week of July until the second week of August. In the second week of August, basil and thyme plants were visited by bees at the same time, and bee visitation continued until the last week of September. In 2022, the bee visitation period started with lavender in the last days of the second week of June and continued for about 16 weeks until the last days of the first week of October. The lavender plant started bee visitation at approximately the same time period in both years, but in the second year, it was visited by bees for two weeks longer, possibly due to the age of the plant. In the first year, basil and thyme were visited by bees at the same time, while in the second year basil was visited by bees five weeks earlier than thyme. It is thought that the difference in the day of bee visitation between basil and thyme in the second year is due to the fact that basil was planted as seedlings, while thyme was planted as seeds, and basil has a gradual flowering biology (Table 3). To provide flowering plants in the early spring or summer period, when the plants used in the study are flowerless (one honey season in the region), it is necessary to ensure the active functioning of the pasture for one season. Therefore, plants that can bloom during these specific periods should be utilized. In addition, plants should be selected in accordance with the climate and soil conditions of the areas where bee pasture will be established, and plants should be planted using different planting times.

Evaluation of lavender in terms of beekeeping

In 2021 and 2022, the data on the number of bees, visit duration of bees, plant height, number of flower stalks per plant, number of flowers per stalk and number of flowers per plant is given in Table 4. According to the data obtained from lavender 2021, the number of bees (q: .75) and plant height (q: .65) were found to be statistically significant at the 5% level, and all other traits (duration of bees' visit (q: .87), flower stalks per plant (q: .74), flowers per stem (q: .77), and flowers per plant (q: .79) were found to be statistically significant at the 1% level. In 2022, all traits (number of bees (q: .66), plant height (q: .70), visit duration of bees (q: .89), flower stalks per plant (q: .76), flowers per stalk (q: .84), and flowers per plant (q: .85) were found to be statistically significant at the 5% level.

Table 4. Data obtained from lavender plots

Çizelge 4. *Lavanta parsellerinden elde edilen veriler*

Year 2021						
Counting time	**Number of bees (pcs.)**	**Visit duration of bees (sec)**	**Plant height (cm)**	**Flower stems per plant (pcs)**	**Flowers per stem (pcs)**	**Flowers per plant (pcs)**
07.06.2021	34.2 ab[1]*	1.6 bc**	42.5 b*	82 b**	1.7 b**	143 c**
10.06.2021	63.5 a	1.7 bc	49.5 ab	149 ab	1.6 b	242 c
14.06.2021	44.5 ab	2.7 ab	49.5 ab	151 a	7.3 ab	1157 abc
17.06.2021	36.2 ab	3.5 ab	49.5 ab	177 a	8.5 ab	1494 ab
21.06.2021	18.5 ab	3.9 a	54.0 ab	178 a	10.7 a	1902 a
24.06.2021	4.2 b	3.7 a	56.5 ab	154 a	10.6 a	1615 ab
28.06.2021	2.7 b	3.5 ab	58.0 a	127 ab	6.3 ab	807 abc
01.07.2021	0.1 b	0.1 c	58.0 a	114 ab	4.1 ab	556 bc
Average	**25.5**	**2.6**	**52.2**	**141**	**6.4**	**989**
CV value (%)	13.1	11.8	9.3	16.7	9	7.2
Year 2022						
13.06.2022	214.8 a**	1.5 d**	42.0 bc**	135 bc**	6.7öd	930 c**
16.06.2022	138.7 ab	4.8 ab	47.5 abc	88 c	10.3	905 c
20.06.2022	175.2 a	4.5 abc	55.0 ab	147 bc	11.5	1676 bc
23.06.2022	206.7 a	4.4 abc	52.0 abc	324 abc	10.4	3506 b
27.06.2022	141.7 ab	4.6 abc	52.0 abc	214 bc	10.4	2156 bc
30.06.2022	120.8 abc	4.4 abc	49.0 abc	313 abc	7.5	2364 bc
04.07.2022	38.7 bc	5.8 a	50.0 abc	303 abc	9.3	2806 bc
07.07.2022	25.0 bc	4.6 abc	50.0 abc	245 bc	6.8	1487 bc
12.07.2022	26.3 bc	4.6 abc	59.0 a	225 bc	8.5	1956 bc
14.07.2022	30.5 bc	3.8 bc	41.0 bc	564 a	10.7	6035 a
18.07.2022	6.8 c	3.2 c	39.0 c	415 ab	5.7	1851
Average	**102.3**	**4.2**	**48.8**	**270**	**8.9**	**2334**
CV value (%)	18.6	6.9	10.3	6.7	11	8.3

[1] Levels not connected by same letter are significantly different (Tukey's HSD, $p<0.05$), **: $p\leq0,01$, *: $p\leq0.05$, omitted: not significant.

For the parameters of the number of bees per square meter and the visit duration of bees, the value obtained in the second year was higher than the value obtained in the first year. The first and second year dataset obtained from plant height was close to each other. The values obtained in the second year for the parameters of number of flower stalks per plant, number of flowers per stem and number of flowers per plant were higher than the first year. In 2021, bees visited lavender mostly between June 7-21 and stayed in the flower the most between June 14-28. In 2022, the bees visited lavender mostly between June 13-30 and spent the most time on the flowers between June 16 and July 12. In 2021, the highest plant height was determined on June 07, and in 2022, it was determined between June

16 and July 12. In 2021, the highest number of flower stalks per plant was determined after June 7, and in 2022, the highest number of flower stalks per plant was determined on June 23, 30, and July 4, 14, and 18. In 2021, the highest number of flowers per stem was determined after June 14. The maximum number of flowers per plant was determined in 2021 between June 14-28, and in 2022 on July 14. Since lavender is a perennial plant, it shows increasing development each year. Therefore, it is seen that this situation causes the plant to bloom more in 2022 than in 2021, to stay in flower for a longer period of time, and ultimately to be visited more by bees, with bees staying in flower longer.

In previous studies on lavender: plant height was 46.14-59.80 cm, and the number of branches was 37.44-42.62 pcs/plant under Konya ecological conditions (Atalay, 2008). Plant height was 67.4-86.1 cm under Isparta ecological conditions (Aslancan, 2016). Plant height was 33.63-42.66 cm, flower stem length was 18.13-19.26 cm, and dry berry yield was 12-200 kg/ha and 17-280 kg/ha under Adana ecological conditions (Balcı, 2019). Under Central Anatolian ecological conditions, plant height was 42-81 cm in the first year and 38-82 cm in the second year, stalked fresh flower weight was 90-500 kg/ha and 120-1000 kg/ha, and dry drug yield was 12-200 kg/ha and 17-280 kg/ha (Şekerci, 2019). Plant height was 16.64-30.95 cm under Niğde ecological conditions (Noory, 2020), and the number of fresh flowers obtained from plants under Dobrich ecological conditions was 721.7-576.7 (Georgieva et al., 2021). It was 49.55-54.13 cm in plant height in Aydın ecological conditions (Akçay et al., 2021), 383.24-585.55 g fresh herb yield and 66.17-111.80 g dry herb yield in Harran plain ecological conditions (Balyemez, 2014), and 355.98-598.93 kg/ha average fresh stemmed flower yield in Çanakkale ecological conditions (Kalyoncu, 2021). These previous findings by the researchers are similar to the findings of the present study in certain aspects.

Evaluation of basil in terms of beekeeping

In 2021 and 2022, the number of bees, visit duration of bees, plant height, number of flower stalks per plant, number of flowers per stems, and number of flowers per plant are given in Table 5. According to the data obtained from basil in 2021, plant height (q: 0.60) is statistically significant at the 5% level. All other traits (number of bees (q: 0.90), visit duration of bees (q: 0.93), flower stalks per plant (q: 0.85), flowers per stem (q: 0.77), flowers per plant (q: 0.67) were statistically significant at the 1% level. In 2022, all traits (number of bees (q: 0.82), plant height (q: 0.92), duration of bee in flower (q: 0.75), flower stalk per plant (q: 0.93), flower per stem (q: 0.90), flower per plant (q: 0.77) were statistically significant at the 5% level.

The data obtained in the first year for the number of bees per square meter, the duration of bees in flower, plant height and the number of flower stalks per plant were all lower than the data obtained in the second year. The data obtained from the number of flowers per stem and the number of flowers per plant were higher in the first year than in the second year. In 2021, bees made the most visits to basil on August 19, while August 16 and September 21 were the dates when they stayed longest in the flowers. In 2022, bees visited basil on August 25; however, August 11 was the date when bees stayed in the flowers the longest. The highest plant height was determined after August 16 in 2021 and after August 18 in 2022. In 2021, the highest number of flower stalks per plant was determined on September 13-23, and in 2022, the highest number of flower stalks per plant was determined on September 3. In 2021, the highest number of flowers per stem was determined between August 16 and September 21, and in 2022, the highest number of flowers per stem was determined between August 04 22. The maximum number of flowers per plant was determined after August 16 in 2021; in 2022, it was determined between August 15 and September 12.

In previous studies on basil: plant height ranged from 38.5-32.5 cm, green herb yield from 1905.7-2826.4 kg/da, and dry herb yield from 403.0-509.0 kg/da in Ankara ecological conditions (Moghaddam, 2010). Plant height ranged from 27.98-48.61 cm, number of branches from 7.65-11.10, green herb yield from 2318.06-2874.32 kg/da, and dry herb yield from 643.14-945.16 kg/da (Cabar, 2016). Plant height ranged from 39.34 to 12 cm in Assam ecological conditions (Chutia et al., 2016). Plant height ranged from 17.16-45.33 cm, green herb yield from 195.00-383.99 g/plant, dry herb yield from 22.21-46.85 g/plant under Ordu ecological conditions (Karaca, 2017). Plant height ranged from 76.73 to 34.55 cm under İzmir ecological conditions (Sönmez et al., 2019). Green herb yield ranged from 1971.3-3718.0 kg/ha and dry

herb yield from 316.0-666.2 kg/ha under Samsun ecological conditions (Özkan, 2014). Green herb yield was 2193.1 kg/ha and dry herb yield was 398.9 kg/ha under Erzurum ecological conditions (Toktay, 2017). Total green herb yields ranged from 1762.2-5174.2 kg/ha and 995.1-4151.3 kg/ha (Açıkbaş, 2018). Green herb yield ranged from 562.28-1998.19 kg/ha and dry herb yield ranged from 72.92-235.18 kg/ha under Ordu ecological conditions (Özcan, 2014). Green herb yield ranged from 201.9-293.9 g/plant and dry herb yield from 31.1-71.4 g/plant under Ankara ecological conditions (Özgen, 2014). It is seen that these findings obtained previously by the researchers are similar to the current study at some points.

Table 5. Data obtained from basil plots

Çizelge 5. *Fesleğen parsellerinden elde edilen veriler*

Year 2021						
Counting Time	**Number of bees (pcs)**	**Visit duration of bees (sec)**	**Plant height (cm)**	**Flower stalks per plant (pcs)**	**Flowers per stem (pcs)**	**Flowers per plant (pcs)**
11.08.2021	9.7 c[1]**	2.6 cde**	43.2 b*	12.0 d**	8.0 bc**	96 b**
16.08.2021	25.2 b	4.3 a	49.0 ab	17.5 cd	15.3 abc	268 ab
19.08.2021	42.8 a	2.6 cde	49.0 ab	21.2 bc	15.2 abc	322 ab
23.08.2021	4.7 c	2.0 e	51.2 a	21.3 bc	16.6 ab	367 ab
26.08.2021	1.7 c	2.4 cde	49.3 ab	22.5 bc	20.3 a	452 a
30.08.2021	3.2 c	2.1 e	50.2 a	21.8 bc	20.5 a	444 a
02.09.2021	8.5 c	2.3 de	50.3 a	20.4 bc	17.9 a	365 ab
06.09.2021	10.5 c	3.1 bc	50.5 a	20.9 bc	21.0 a	439 a
09.09.2021	12.5 bc	3.0 bcd	51.0 a	22.7 bc	19.4 a	438 a
13.09.2021	11.0 c	2.5 cde	50.4 a	26.4 ab	13.9 abc	367 ab
16.09.2021	10.8 c	2.9 cd	51.6 a	26.1 ab	15.8 ab	414 a
21.09.2021	7.2 c	4.4 a	51.1 a	27.5 ab	14.9 abc	428 a
23.09.2021	3.2 c	3.7 ab	50.9 a	30.8 a	6.4 c	189 ab
Average	**11.6**	**2.9**	**49.8**	**22.4**	**15.8**	**353**
CV value (%)	22.4	8.8	4.4	11	19.5	15.5
Year 2022						
28.07.2022	8.2 cde**	2.9 bcd**	40.5 g**	11.5 i**	2.5 abc**	29 de**
01.08.2022	8.2 cde	4.7 ab	56.0 cde	12.0 i	2.2 bcd	26 de
04.08.2022	13.3 b-e	3.1 bcd	45.0 fg	15.0 hi	3.6 a	54 b-e
08.08.2022	12.7 b-e	2.9 bcd	46.5 efg	23.0 f-i	2.4 a-d	55 b-e
11.08.2022	11.0 b-e	5.2 a	47.5 efg	16.0 ghi	1.5 c-f	22 de
15.08.2022	10.3 b-e	3.3 bcd	59.5 bcd	33.5 def	3.7 a	123 ab
18.08.2022	25.7 ab	4.2 abc	61.5 a-d	32.5 d-g	3.2 ab	112 abc
22.08.2022	22.0 bc	3.8 a-d	64.5 a-d	43.0 cde	3.3 ab	145 a
25.08.2022	42.5 a	3.9 a-d	61.0 a-d	31.5 e-h	2.1 b-e	67 a-e
29.08.2022	14.3 b-e	3.0 bcd	67.5 ab	47.0 b-e	0.8 efg	37 cde
01.09.2022	19.0 bcd	3.5 a-d	67.0 ab	51.5 bc	1.7 c-f	87 a-d
05.09.2022	18.8 bcd	3.2 bcd	60.5 a-d	61.5 ab	2.0 b-e	124 ab
08.09.2022	7.7 cde	3.1 bcd	66.5 ab	43.0 cde	2.0 b-e	89 a-d
12.09.2022	10.0 b-e	2.3 d	55.0 def	41.5 cde	1.7 c-f	69 a-e
15.09.2022	12.5 b-e	2.7 cd	69.0 ab	49.5 bcd	1.1 d-g	57 b-e
19.09.2022	11.3 b-e	2.6 cd	66.5 ab	51.0 bc	0.5 fg	24 de
22.09.2022	0.8 e	2.4 cd	61.0 a-d	37.5 c-f	0.8 efg	29 de
26.09.2022	7.3 cde	2.1 d	69.0 ab	46.5 b-e	0.8 efg	39 cde
29.09.2022	at 3.7	2.2 d	69.5 ab	51.0 bc	1.6 c-f	82 a-e
03.10.2022	9.7 b-e	2.6 cd	70.5 a	70.5 a	1.1 d-g	78 a-e
06.10.2022	0.7 e	3.1 bcd	66.0 abc	35.0 c-f	0.1 g	5 e
Average	**12.8**	**3.2**	**60.5**	**38.3**	**1.8**	**64**
CV value (%)	26	18.3	5.4	14.6	23.2	27.7

[1] Levels not connected by same letter are significantly different (Tukey's HSD, $p<0.05$), **: $p\leq0,01$, *: $p\leq0.05$, omitted: not significant.

Evaluation of thyme in terms of beekeeping

In 2021 and 2022, the number of bees, visit duration of bees, plant height, flower stalks per plant, number of flowers per stalk, and number of flowers per plant are presented in Table 6. According to the data obtained from thyme 2021, the number of plants in m2 (q: 0.06) was insignificant, while all other traits (number of bees (q: 0.88), plant height (q: 0.78), visit duration of bees (q: 0.76), number of flowers per square meter (q: 0.85), flowers per plant (q: 0.88) were statistically significant at the 5% level, while in 2022, all traits (number of bees (q: 0.91), plant height (q: 0.67), bee flowering time (q: 0.82), number of plants per square meter (q: 0.76), number of flowers per square meter (q: 0.82), flowers per plant (q: 0.97) were statistically significant at the 5% level.

Table 6. Data obtained from thyme plots

Çizelge 6. *Kekik parsellerinden elde edilen veriler*

Year 2021						
Counting time	**Number of bees (pcs)**	**Visit duration of bees (sec)**	**Plant height (cm)**	**Flowers per plant (pcs)**	**Number of plants per square meter (pcs)**	**Number of flowers per square meter (pcs)**
11.08.2021	46.0 b[1]**	1.6 cd**	21.4 b**	9.2 bcd**	184öd	1619 bc**
16.08.2021	50.0 b	2.2 a-d	28.3 a	12.4 ab	209	2749 ab
19.08.2021	80.3 ab	2.0 a-d	27.8 a	14.2 ab	219	3098 ab
23.08.2021	90.3 a	2.1 a-d	28.3 a	14.7 ab	218	3204 ab
26.08.2021	50.0 b	3.0 ab	30.6 a	18.3 a	219	4032 a
30.08.2021	50.6 b	3.2 a	31.8 a	18.3 a	216	3964 a
02.09.2021	50.7 b	2.8 abc	30.1 a	18.3 a	209	3808 a
06.09.2021	48.3 b	1.9 bcd	31.3 a	18.0 a	213	3686 a
09.09.2021	50.7 b	1.8 bcd	32.4 a	18.1 a	209	3782 a
13.09.2021	51.0 b	1.7 cd	32.9 a	10.7 abc	208	2226 abc
16.09.2021	10.3 c	1.7 cd	29.9 a	8.1 bcd	210	1690 bc
21.09.2021	10.3 c	1.8 bcd	29.3 a	2.1 d	210	442 c
23.09.2021	2.7 c	1.1 d	30.0 a	3.3 cd	214	709 c
Average	**45.5**	**2.1**	**29.5**	**12.7**	**211**	**2693**
CV value (%)	16.9	20.1	6.8	19.9	20.1	13.1
Year 2022						
05.09.2022	85.7 ab**	2.1 d**	27.7 b**	7.9 cd**	179 bc**	1418 c**
08.09.2022	113.3 a	2.6 bcd	27.3 b	9.7 bc	215 abc	2097 bc
12.09.2022	54.3 bc	3.3 ab	27.1 b	5.3 ef	265 ab	1398 c
15.09.2022	79.3 ab	2.8 bcd	34.7 a	8.8 cd	252 ab	2221 bc
19.09.2022	84.0 ab	2.3 d	30.5 ab	7.2 de	230 abc	1665 bc
22.09.2022	56.7 bc	2.4 cd	28.3 ab	8.7 cd	264 ab	2294 abc
26.09.2022	40.3 cd	2.8 bcd	30.0 ab	11.5 b	255 ab	2958 ab
29.09.2022	102.7 a	2.4 cd	28.7 ab	14.7 a	245 ab	3597 a
03.10.2022	40.3 cd	3.6 a	30.8 ab	4.2 f	291 a	1222 c
06.10.2022	3.3 d	3.1 abc	33.5 ab	9.7 bc	147 c	1429 c
Average	**66.0**	**2.7**	**29.9**	**8.8**	**234**	**2030**
CV value (%)	19.8	9.9	7.4	7.8	13.1	22

[1] Levels not connected by same letter are significantly different (Tukey's HSD, $p<0.05$), **: $p\leq0,01$, *: $p\leq0.05$, omitted: not significant.

The data obtained in the first year of the study for parameters such as the number of bees per square meter, visit duration of bees, plant height, and number of plants per square meter were lower than the data obtained in the second year. The average values obtained from the number of flowers per plant

and number of flowers per square meter in the first year were higher than those in the second year. In 2021, bees visited thyme mostly on August 19 and 23 and stayed in the flower the most between August 16 and September 2. In 2022, bees visited thyme mostly on August 08 and September 29; October 03 was the date when bees stayed on the flowers longest. In 2021, the highest plant height was determined after August 16, and in 2022, after September 15. The highest number of flowers per plant was determined between August 16 and September 13 in 2021, and on September 29 in 2022. In 2022, the maximum number of plants per square meter was determined between September 08, and October 03. In 2021, the maximum number of flowers per m2 occurred from August 16 to September 13, and in 2022, from September 22 to 29.

In the previous studies on thyme, the average plant height for the first study year in Ankara ecological conditions was 24.8-78.0 cm, total green herb yield was 1712-5274 kg/da, total herb yield was 483-1537 kg/da, the average plant height for the second study year was 26.52-85.32 cm, total green herb yield 1546-6955 kg/da, total drog herb yield 454-2110 kg/da (Baghdad, 2011), plant height varied between 21.60-60.43 cm on average in Tekirdağ ecological conditions, the highest green herb yield was 430.67 kg/da (Gürtunca, 2011), the average plant height of Origanum dubium genotype under Karaman ecological conditions ranged between 40.36-45.73 cm, green herb yield ranged between 99.85-101.16 g/plant, dry herb yield ranged between 43.53-48.0 g/plant, *Origanum husnucan-baseri* plants had a mean plant height of 74.61-73.12 cm, green herb yield of 463.40-247.62 g/plant, dry herb yield of 193.31 97.05 g/plant, *Origanum vulgare* subsp. hirtum plants, mean plant height 68.66-69.22 cm, green herb yield 333.23-320.27 g/plant, dry herb yield 150.54-139.55 g/plant, *Thymus sipyleus* plants, mean plant height 14.51-28.69 cm, green herb yield 50.58-34.39 g/plant, dry herb yield 22.24-35.82 g/plant (Maral, 2018), the highest green herb yield 222.45-714.63 kg/ha, the highest dry herb yield 64.30-256.74 kg/ha, average plant height 25.05-43.64 cm under Ordu ecological conditions (Sonkaya, 2019), under Diyarbakır ecological conditions, thyme species *Satureja hortensis* L., *Thymbra spicata* L., *Origanum* sp. plant heights ranged between 34.66, 27.00, 47.79 cm, green herb yields of *Satureja hortensis* L. 1794.33 kg/da, *Thymbra spicata* 1367.50 kg/da and *Origanum* sp. 1277.28 kg/da (Asan & Ekinci, 2020). It is seen that these findings obtained previously by the researchers are similar to the findings of the current study in some points.

Two-year averages of the parameters used in the study such as number of bees, visit duration of bees (sec), plant height (cm), number of plants per m2, number of flowers per m2, flower stalks per plant (pcs.), flowers per stem (pcs.), flowers per plant (pcs.), green herb weight (g) and dry herb weight (g) are given in Table 7.

Table 7. Two-year average values of the analyzed parameters

Çizelge 7. *İncelenen parametrelerin iki yıllık ortalama değerleri*

	Lavender	**Basil**	**Thyme**
Number of bees (pcs)	63.9	12.2	55.8
Visit duration of bees (sec)	3.5	3.1	2.4
Plant height (cm)	50.5	55.2	29.7
Number of plants per square meter (number)	2	4	223
Number of flowers per square meter (number)	3323	834	2362
Flower stalks per plant (pcs.)	206	30.4	-
Flowers per stem (pcs)	7.65	8.8	-
Flowers per plant (pcs)	1662	209	10.8
Green herb weight (g)	571	745	525
Dry herb weight (g)	195	208	162

According to the two-year average data, the highest values in terms of the number of bees and the flowers per square meter were provided by lavender, thyme, and basil, respectively. The highest values in terms of visit duration of bees and number of flowers per plant were provided by lavender, basil, and thyme, respectively. The highest values in terms of plant height, dry herb and green herb were provided by basil, lavender and thyme, respectively.

Correlation tables

The number of bees, the visit duration of bees on the flower, and the correlation analysis of the parameters: plant height and number of flowers per plant are given in tables 8, 9, and 10.

Table 8. Two-year correlation coefficients of traits obtained from lavender plants

Çizelge 8. *Lavanta bitkisinden elde edilen özeliklere ait iki yıllık korelasyon katsayıları*

	Number of	Visit duration of bees	Plant height	Flowers per plant
Number of bees	1			
Visit duration of bees	.1278	1		
Plant height	-.2081	.0505	1	
Flowers per plant	.0533	.4411*	-.3346	1

Pearson correlation, *: $p \leq 0.05$.

There was a statistically significant correlation between flowers per plant and visit duration of bees (r: .4411) at the significance 5% significance level. There was a weak positive correlation between bee flowering time and the number of bees, plant height and bee flowering time, and flowers per plant and the number of bees. There was a weak negative correlation between plant height and number of bees. There was a moderate positive correlation between flowers per plant and the duration of bee visits. There was a moderate negative correlation between flowers per plant and plant height.

Table 9. Two-year correlation coefficients of traits obtained from basil plants

Çizelge 9. *Fesleğen bitkisinden elde edilen özeliklere ait iki yıllık korelasyon katsayıları*

	Number	Visit duration of bees	Plant	Flowers per
Number of bees	1			
Visit duration of bees	.3193*	1		
Plant height	.0155	-.0889	1	
Flowers per plant	-.0428	-.1769	-.4552	1

Pearson correlation, *: $p \leq 0.05$.

There was a statistically significant correlation at the 5% level (r: 3193) between the visit duration of bees and the number of bees. There was a moderate positive correlation between the number of bees and the visit duration. There was a weak positive correlation between plant height and the number of bees. Weak negative correlations were found between plant height and bee flowering time; flowers per plant and number of bees; flowers per plant and bee flowering time. There was a moderate negative correlation between flowers per plant and plant height.

Table 10. Two-year correlation coefficients of traits obtained from thyme plants

Çizelge 10. *Kekik bitkisinden elde edilen özeliklere ait iki yıllık korelasyon katsayıları*

	Number	Visit duration of bees	Plant	Flowers per
Number of Bees	1			
Visit duration of bees	.1481	1		
Plant Height	-.2188	.2446	1	
Flowers per Plant	.2903	.1117	.1777	1

Pearson correlation, *: $p \leq 0.05$.

No statistically significant difference was found between the traits. There was a weak negative correlation between plant height and number of bees. Weak positive correlations were found between flowers per plant and number of bees, flowers per plant and bee flowering time, flowers per plant and plant height, plant height and bee flowering time, and bee flowering time and number of bees. In lavender

and thyme plants, the number of bees, the visit duration of bees, and the number of flowers per plant are positively correlated with plant height in the same plants. This relationship in lavender and thyme is considered positive for bee pasture. In basil, unlike in many other plants, the number of flowers per plant has an inverse relationship with all other traits.

Graphics about bee plant relationship

The distribution of the number of bees, visit duration of bees, plant height, number of flowers in m2, green herb weight, and dry herb weight in 2021, 2022, and two-year average values are given in Figure 1.

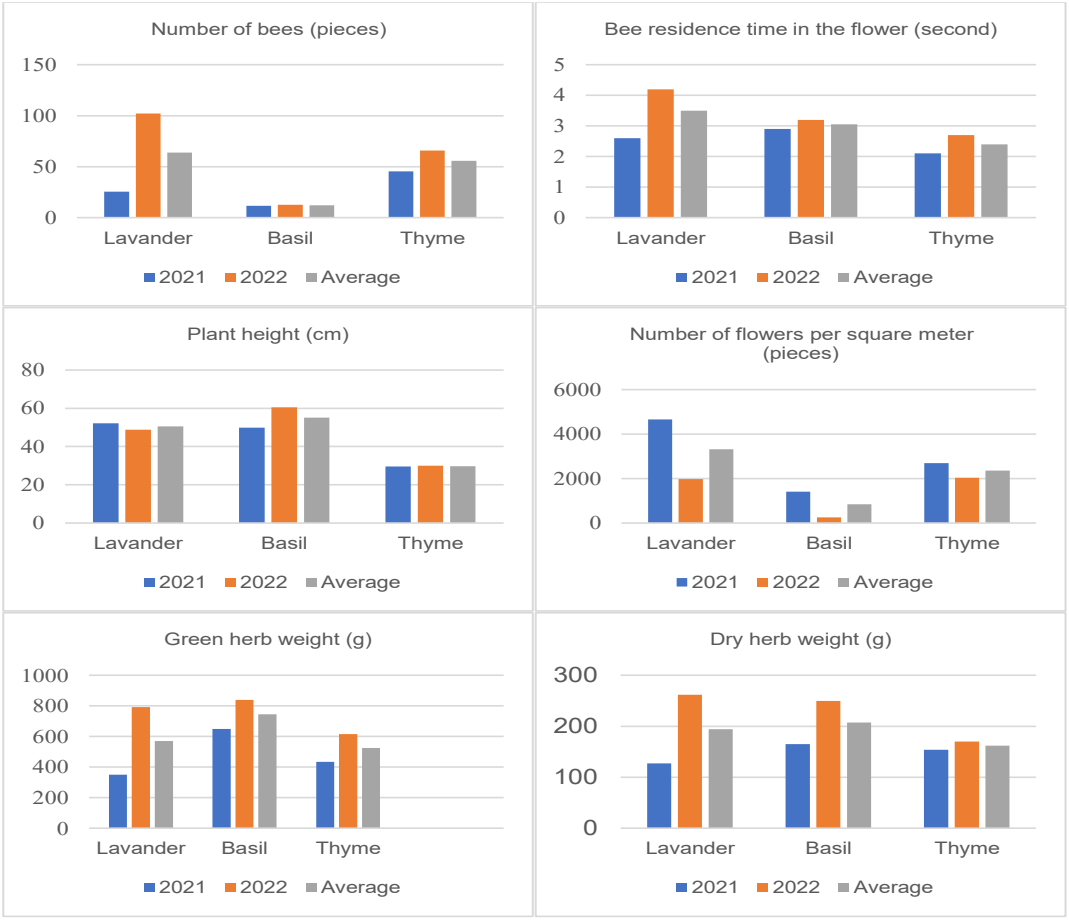


Figure 1. Graphical distribution of some yield characters used in the study.

Şekil 1. *Çalışmada kullanılan bazı verim karakterlerinin grafiksel dağılımı.*

The number of bees was highest in the second year of the lavender plant, while the lowest value was observed in the first year of the the basil plant. The lowest value was obtained from the first year of thyme plants, while the highest value was obtained from the second year of lavender plants. In terms of plant height, the lowest value was obtained from the first-year thyme plant, while the highest value was obtained from the basil plant. In terms of the number of flowers per square meter, the highest value was obtained from the first year of lavender, while the lowest value was obtained from the second year of basil. In terms of green herb weight, the highest value was obtained from the second year of the basil plant, while the lowest value was obtained from the first year of the lavender plant. In terms of dry herb weight, the highest value was obtained from the second year of lavender, while the lowest value was obtained from the first year of the same plant.

CONCLUSIONS

It was determined that lavender parameters have a significant potential for bee pasture in each year, with slight differences in the first year due to developmental biology. It is thought that the basil plant has the potential to create bee pasture based on parameter analyses specific to the years. However, due to seedling production from seed, the plants have developed differently, and this difference is reflected in the two-year averages. It was determined that the characteristics of the thyme plant, examined over the years, have the potential to create bee pasture. According to the two-year average, basil was the plant most open to bee visitation, followed by thyme and lavender. Lavender was the most preferred plant by bees, followed by thyme and basil. Bees spent the most time on lavender flowers and the least time on thyme flowers. Lavender had the highest number of flowers per square meter, while basil had the lowest. According to the two-year averages, the positive correlations between the number of bees, the visit duration of bees and the number of flowers per plant in lavender and thyme plants are promising for bee pasture. According to the two-year averages, although the number of flowers per plant in basil has an inverse relationship with all other characteristics, which negatively impacts bee pasture, its ability to attracts a certain amount of bees by flowering during periods when other plants do not provide flowers and by flowering gradually over a long duration makes this plant a potential alternative in bee pasture. These plants have the potential to be used directly as bee pasture in Bingöl province and similar ecological conditions. However, when they are grown for their medicinal and aromatic properties, they can be preferred as a habitat for bees during a specific period. Although lavender, basil, and thyme plants are considered medicinal and aromatic plants, they serve as an excellent bee pasture if harvesting is done towards the end of flowering. It is thought that utilizing agriculturally produced plants in different ways during the same vegetation period is gaining importance day by day, and additionally, using plants as bee pasture at the same time will provide economic benefits. To utilize the relationships honeybees have with plants more effectively, it is necessary to conduct studies such as using alternative plants with a long flowering period or experimenting with different planting times of annual plants during periods when flowers are not available from the plants under study.

Data Availability

Data available upon reasonable request.

Author Contributions

Concept and design of the study: RU, KK, EA; sample collection: RU, KK, EA; data analysis and interpretation: RU, KK, EA; statistical analysis: RU, KK, EA; visualization: RU, KK, ES; writing the article: RU, KK, ES.

Conflict of Interest

There is no conflict of interest between the authors in this study.

Ethical Statement

We declare that there is no need for an ethics committee for this research.

Financial Support

This study was financially supported by Bingöl University Scientific Research Projects Coordination Office (BAP, PIKOM-Bitki.2019.001).

Article Description

This article was edited by Section Editor Prof. Dr. Hakan GEREN.

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