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The effect of farmyard manure on seed yield and yield components of broad bean (*Vicia faba* L.) varieties*

Çiftlik gübresinin Bakla (*Vicia faba* L.) çeşitlerinde tane verimi ve verim unsurlarına etkisi

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ABSTRACT

Objective: In this study, it was planned to examine the effects of farmyard manure on seed yield and yield components of different broad bean varieties.

Material and Methods: The study was carried out in the ecological conditions of Mentese district of Muğla province in the 2021-2022 broad bean planting season. Seed yield and some yield components of farmyard manure doses (0-3000-6000 kg ha^{-1}) in Histal, Salkim, Major and Golyaka varieties were examined. The study was planned with split-plot over randomized complete block design.

Results: The interaction between farmyard manure and the variety has been observed to be significant for the number of flowering days, physiological maturity duration, number of pods per plant, number of seeds per pod, number of seeds per plant and the weight of 100 seeds. Among the traits, the farmyard manure factor was found to be statistically significant in traits such as plant height and first pod height, while the variety factor was significant in the protein ratio. In terms of grain yield, both farmyard manure and variety factors were found to be statistically significant. The optimal grain yield, significantly affected by the amount of barn manure doses, was recorded at 2642 kg ha^{-1} at a dose of 6000 kg ha^{-1}. Among the varieties, Histal variety stands out for its protein content, with a value of 23.5%.

Conclusion: The effects of farmyard manure application on grain yield and yield components of pods were found to be significant. As a result of the study, it was determined that it was important to contine the experiment for more than one yearin order to observe the positive effects of barn manure application on the examined traits.

Keywords: Broad bean, farmyard manure, grain protein rate, yield

ÖZ

Amaç: Bu çalışmada çiftlik gübresinin farklı bakla çeşitlerinde tohum verimi ve verim unsurları üzerine etkilerinin incelenmesi planlanmıştır.

Materyal ve Yöntem: Çalışma Muğla ili Menteşe ilçesi ekolojik koşullarında 2021-2022 bakla ekim sezonunda yürütülmüştür. Histal, Salkim, Majör ve Golyaka çeşitlerinde çiftlik gübresi dozlarında (0-3000-6000 kg ha^{-1}) tohum verimi ve bazı verim bileşenleri incelenmiştir. Araştırma tesadüf bloklarında bölünmüş parseller deneme desenine göre üç tekrarlamalı olarak planlanmıştır.

Sonuçlar: Çiftlik gübresi ile çeşit arasındaki interaksiyonunun çiçeklenme gün sayısı, fizyolojik olgunlaşma süresi, bitkide bakla sayısı, baklada tane sayısı, bitki başına tane sayısı ve 100 tane ağırlığı özelliklerinde önemli olduğu gözlenmiştir. Özellikler arasında çiftlik gübresi faktörünün bitki boyu ve ilk bakla yüksekliği gibi özelliklerde istatistiksel olarak önemli olduğu, çeşit faktörünün ise protein oranında önemli olduğu tespit edilmiştir. Tane verimi açısından ise hem çiftlik gübresi hem de çeşit faktörü istatistiksel olarak önemli bulunmuştur. Ahır gübresi dozunun miktarından önemli ölçüde etkilenen optimum tane verimi ise 6000 kg ha^{-1} dozunda, 2642 kg ha^{-1} olarak kaydedilmiştir. Çeşitler arasında Histal çeşidi %23.5 protein içeriği ile ön plana çıkmaktadır.

Sonuç: Çiftlik gübresi uygulamasının tane verimi ve bakla verim unsurları üzerine etkisi önemli bulunmuştur. Çalışma sonucunda ahır gübresi uygulamasının incelenen özellikler üzerindeki olumlu etkilerinin gözlemlenebilmesi için denemenin birden fazla yıl devam ettirilmesinin önemli olduğu belirlenmiştir.

Anahtar kelimeler: Bakla, ahır gübresi, tane protein oranı, verim

INTRODUCTION

Legumes are an important group with a long history, used in human nutrition and constituting the main source of vegetable protein. The rich nutritional value of legumes, they also have a significant impact on the environment by fixing atmospheric nitrogen into the soil. It is one of the legumes being integrated into smallholder farming systems to improve soil fertility through atmospheric dinitrogen (N2) fixation and serve as a cost-effective source of protein (Ruisi et al., 2017; Etemadi et al., 2018). Legumes are grown on 81 million hectares out of the 1.5 billion hectares of agricultural land worldwide (Kardes et al., 2019). On the other hand, legumes are grown on 790 thousand hectares of the 23 million hectares of agricultural land in Türkiye. However, pod yields are low throughout the country and are around the world average (1700 kg/ha) (FAOSTAT, 2022).

In terms of fiber, protein and minerals, broad bean meets the daily macronutrient and micronutrient requirements (Abiodun et al., 2022). It is used in a wide variety of human nutrition. Broad beans, which can be consumed raw or roasted, are also enjoyed fresh as shelled inner broad beans. The grain is dried, boiled, and at the same time, the dish called Fava, which is made by crushing, is also very well-known. In the same way, broad bean flour is obtained by grinding dried broad beans. It improves the soil and contributes to increased yields by rotating with other crops in broad bean cultivation. Faba bean is beneficial to cropping systems, playing an important role in crop rotation with cereals by disrupting the disease cycles of various pathogens and pests (Rose et al., 2016; de Notaris et al., 2023; Seha et al., 2023).

The fertilizer used to increase the yield and quality of pods is also very effective in increasing grain yield. While chemical fertilization used in agriculture increases production, it also has negative effects on soil, the environment and human health. Given that fertilization will persist in agricultural soils, opting for organic fertilizers instead of chemical ones can enhance the sustainability of agriculture. Farmyard manure, classified as organic matter, plays a crucial role in enhancing soil structure and increase plant yield and quality (Karayel et al., 2020).

The primary goal of modern agriculture is to ensure high-quality and efficient production from a given unit area without causing harm to the environment and soil. This goal is directly related to fertilization and other criteria. The chemical fertilizers used cause deterioration in the structure of the soil and lead to salt accumulation in the soil. Furthermore, it causes groundwater and soil pollution over many years. To prevent these negative effects, farmyard manure is preferred as organic fertilizer (Norman & Dazzo, 2016). Previous studies have shown that crops can only take up 30-50% of chemical fertilizers. As a result, a significant amount of the applied components is lost in the soil, where they pollute groundwater (Mozner et al., 2012). Furthermore, Nitrogen Use Efficiency (NUE) has decreased over the last few decades, leading to a significant amount of excess nitrogen fertilizer being lost to the environment There are several ways to control the increasing use of chemical fertilizers. The most important way among these is the widespread use of farmyard manure (Jian et al., 2010; Sabourifard et al., 2023).

Farmyard manure is a storage of organic matter that is beneficial to the soil. It is used to improve soil and plant fertility. It provides the soil with a significant amount of nitrogen (N) and phosphorus (P) and potassium (K) as well as other minerals. The soil acts as a buffer against possible excessive salinity and pH differences (Sultani et al., 2007; Heinze et al., 2010).

The aim of this study was to investigate the effect of farmyard manure, which is more beneficial to soil and the environment, on the yield and some yield characteristics of broad bean as an alternative to chemical fertilizers in broad bean production.

MATERIALS and METHODS

The data on minimum, maximum, average temperature and total precipitation for the months of November to May in 2021-2022 are provided in Table 1. The province of Muğla, where the research was carried out, has a Mediterranean climate.

Table 1. The meteorological data of the experimental year and long years

***Çizelge 1**. Deneme yılı ve uzun yıllara ait meterolojik veriler*

Months	Minimum Temperature (ºC) (2021-2022)	Long years (ºC)	Maximum Temperature (ºC) (2021-2022)	Long years (ºC)	Average Temperature (ºC) (2021-2022)	Long years (ºC)	Total Precipitation (mm) 2021-2022	Long years (mm)
Nowember	1	5.9	23.1	16.7	11.4	10.8	77.2	135.6
December	2	3.2	17.1	11.5	8.0	7.0	133.4	265.0
January	-5	1.6	14.9	9.8	2.2	5.3	161	245.7
February	-4.6	1.9	17.2	11.0	5.4	6.1	140	178.3
March	-2.3	3.5	21.3	14.1	4.1	8.5	111	122.4
April	1.8	7.0	26	18.9	14.3	12.8	93	63.7
May	6	11.4	31.3	24.3	16.9	17.8	81	49.5

Source: Muğla Meteorological Centre. Long years: 1941-2020.

In the study, it was observed (Table 1) that the minimum temperatures during the vegetation period were lower than the long-term average, indicating a colder vegetation period. According to these results, it was observed that the maximum and average temperature values of the experimental year were higher than the long-term averages. The total precipitation amount over the long years (151.5) exceeds the total precipitation amount for 2021-2022 (113.8). When the meteorological data were examined, it was determined that the temperatures observed during the vegetation period occurred in a wider temperature range and lower precipitation surface compared to the long-term averages.

Soil characteristics of the experimental area

The soil sample of the experimental area was analyzed and the results are shown in Table 2. The soil sample was analyzed at "Muğla Sıtkı Koçman University, Agricultural Soil Plant and Irrigation Water Analysis Laboratory”.

According to Table 2, the soil in the experimental area was found to have a moderate organic matter content and a neutral pH level. The amount of potassium (K) was found to be moderate (176.41 ppm), while the amount of phosphorus (P) was found to be very high (50.00 ppm).

Table 2. Soil analysis of the experimental area

***Çizelge 2**. Deneme alanına ait toprak özellikleri*

pH	Organic matter (%)	P (ppm)	K (ppm)
7.22	2.11	50.00	176.41
Nötr	Moderate	Very High	Moderate

Material

Characteristics of farmyard manure in the study

The content analysis of the farmyard manure used in the study was carried out and the results are shown in Table 3. Farmyard manure was applied to the area where soil preparation was made before sowing at a rate of 0-3000-6000 kg/ha.

Farm manure was analysed at "Muğla Sıtkı Koçman University Muğla Agricultural Soil, Plant and Irrigation Water Analysis Laboratory".

The content of farmyard manure is presented in Table 3. In the results, it was determined that farmyard manure was rich in mineral matter content.

Table 3. Analysis of farmyard manure used in the experiment

Çizele 3. *Denemede kullanılan çiftlik gübresi analizi*

Ph (su) (1/10)	EC (1/10) (su) (Mikrosimens)	P (%)	K (%)	Moisture (%)	Ca (%)	Cu (ppm)	Fe (ppm)	Mg (%)	Mn (ppm)	Zn (ppm)
8.14	833	0.51	0.52	37.23	2.63	88.93	14761.8	0.43	894.5	410.8

In the study, four different broad bean varieties were used as materials. The names of the varieties are Histal, Salkım, Gölyaka and Majör. Sowing in the study was carried out in the Menteşe district of Muğla province on November 17, 2021. Hand sowing was carried out in plots consisting of 6 rows, each 5 m in length, with a distance of 25 cm between rows and 10 cm above rows. Each plot was 7.5 square meters in size. The study was conducted using a split-plot experimental design in randomized blocks with three replications. In the study, the main plot consisted of different doses of farmyard manure (0-3000-6000 kg/ha), while the sub-plot included various varieties (Histal, Salkım, Gölyaka, and Majör). After plant emergence and maintenance operations, harvesting was carried out manually on May 30, 2022.

Analysis of characteristics

Observations were made on ten plants from each plot. Days to flowering (days) was calculated as the number of days from the date of emergence to the date of flowering in 50% of the plants. Physiological maturity (days) refers to the number of days from the emergence date to the yellowing of the pods in the middle of the plant crown, encompassing 50% of the plants. Plant height (cm) was determined by measuring the distance from the soil surface to the uppermost point of the plant during the harvest period. First pod height (cm) was determined by measuring the vertical distance from the soil surface to the first fruit-bearing pod on the plant during the harvest period. The number of branches per plant was determined by counting the branches, and the average number of branches per plant was determined as pieces (pcs). Single plant weight (g) was determined by weighing the harvested plants and averaging the average weight.

Number of pods per plant (number), 10 pods were randomly selected from each plot in the study, pods were counted during the harvest period and the average number of pods per plant was determined. Fifteen pods were randomly selected after the complete drying of the harvested pods and the number of grains per pod was determined by taking the average of the collected grains. 100 seed weight (g) was determined by averaging the weight of 100 seeds in 3 replicates randomly selected from the product collected from each plot after the drying of the grain (reaching 14% moisture content).

Seed yield (kg/ha) was calculated in kg/ha from the plants harvested from the area of 7,5 m^2 remaining after the side effects were removed from each plot in the study. For grain protein ratio (%), 100 g dry grain samples taken randomly from each plot in the study were ground into flour and protein analysis was carried out in "NIRS (Near-Infrared Measurements) device at ADU Agricultural Biotechnology and Food Safety Laboratory".

Statistical analyses

The data obtained from the study were analysed by using JMP 13 statistical analysis software in Split-Plot Design over Randomized Complete Block Design.

RESULTS and DISCUSSION

The data obtained from the study were subjected to variance analysis and the mean squares obtained for number of days to flowering, number of days to physiological maturity, plant height, first pod height, number of branches and number of pods per plant are presented in Table 4. According to the results of analysis of variance, the effects of farmyard manure on number of days to flowering, days to physiological maturity, plant height, first pod height and number of pods per plant were found statistically significant, while the effect of farmyard manure on number of side branches was found insignificant. The effects of variety factor on number of days to flowering, number of days to physiological maturity, number of branches and number of pods per plant was statistically significant, while its effects on plant height and first pod height were insignificant. Barn manure*variety interaction was found to be insignificant except for the number of pods per plant.

Table 4. Mean squares of some of the characteristics analysed in the study

Çizelge 4. *Çalışmada incelenen bazı özelliklere ait kareler ortalamaları*

Source of variation	DF	NFD	NPM	PH	FPH	BN	PP
Blocks	2	0.445	0.778	27.840	0.842	0.444	1.361
Farmyard manure	2	28.779*	38.528*	543.382*	15.19*	1.694 ns	97.861*
Error 1	4	2.403	2.861	8.233	1.405	0.444	0.777
Cultivars	3	2.704*	6.593*	57.359 ns	0.516 ns	7.148*	88.333*
FM x C	6	7.260 ns	4.231*	12.512 ns	0.544 ns	0.731 ns	10.194*
Error 2	18	1.713	0.907	21.641	1.831	0.815	1.490
General	35						
CV		1.36	0.711	9.705	11.905	64.992	11.752

NFD: Number of flowering days, NPM: Number of days to physiological maturity, PH: Plant heigh, FPH: first pod height, BN:Branch number, PP:Pods per plant *: significant atP=0.05 **: significant at P=0.01 ns: non significant.

According to the data of the experiment, the analysis of variance results for the number of seeds in a pod, 100-seed weight, seed yield, and seed protein ratio were presented in Table 5. The variance analysis results indicated that the effects of farmyard manure on the number of seeds in a pod, 100-seed weight, and seed yield were statistically significant, while its effect on seed protein ratio was non-significant. However, the effects of cultivars on all traits (Table 5) were found to be statistically significant. The interactions between farmyard manure and cultivar on the number of grains in pods and 100-seed weight were statistically significant, while its effects on seed yield and seed protein ratio were non-significant.

Table 5. The mean squares of the number of grains per plant, 100 seed weight, seed yield and protein ratio analysed in the study

Çizelge 5. *Çalışmada incelenen bitkide tane sayısı, 100 tane ağırlığı, tane verimi ve protein oranına ait kareler ortalamaları*

Source of variation	DF	Seed per Plant	100 Seed Weight	Seed Yield	Seed Protein
Blocks	2	1.023	637.131	223.317	0.270
Farmyard manure	2	15.615*	19720.4*	18402.3*	0.013 ns
Error 1	4	0.326	167.302	89.184	0.558
Cultivars	3	30.018*	20391.8*	3898.29*	7.617*
FM x C	6	1.923*	5284.32*	190.918 ns	1.003 ns
Error 2	18	0.293	482.46	269.23	0.872
General	35				
CV		8.369	12.469	7.450	4.224

*:significant at P=0.05 **: significant at P=0.01ns: non significant.

The number of days to flowering was measured, and the mean values (Table 6) were found between 91.7 and 97.7 days. A short flowering period in legumes is crucial for early flowering. In the study, the earliest number of days to flowering was 91.7 days for the Histal variety with 0 kg/ha of farmyard manure application. In Türkiye, early varieties are preferred especially in legumes which are used in crop rotation system. According to the days to flowering data obtained by Yılmaz & Köse (2023), 116.67 days to flowering was found in Salkım. Pekşen & Gülümser (2006) investigated different legume types and determined that the number of days to flowering was between 72.3 and 132.67, Bozoğlu (1989) observed that the flowering period was 90-94 days in broad bean varieties and lines. Mıdık (2019) studied legume genotypes and found that the number of days to flowering was between 87 and 102 days.

Table 6. The mean values of days to flowering of broad bean cultivars

Çizelge 6. *Bakla çeşitlerinin çiçeklenme gün sayısı özelliğine ait ortalamaları*

Cultivars	Farmyard Manure (kg ha^{-1})			Mean
	0	3000	6000	
Histal	**91.7**±0,68^{b}	96.0±0.79^{a}	97.3±0.30^{a}	95.0
Salkim	92.3±0,52^{b}	**97.7**±0.54^{a}	96.0±0.08^{a}	95.3
Majör	95.7±0,93^{a}	95.7±0.98^{a}	96.3±0.71^{a}	95.9
Gölyaka	95.7±0,79 ^{a}	96.0±0.36^{a}	97.0±0.51^{a}	96.2
Mean	93.8^{B}	96.3^{A}	96.7^{A}	95.6
LSD (Farmyard m.)=1.745				
LSD (Farmyard m.* Cultivars) = 2.245				

The number of days to physiological maturity was measured and the mean values (Table 7) were found between 130.3-136.3 days. The shortest number of days to physiological maturity was observed in the Histal variety at a 0 kg/ha dose of stable manure. The number of days to physiological maturity varies depending on the number of days to flowering. Among the varieties, Salkım matured earliest, while Gölyaka was the latest. Toker (2004) examined some broad bean genotypes and highlighted the significant impact of genotype factor on the number of physiological days. Previous studies have reported the number of days to physiological maturity in broad beans to be between 116-127 days (Kadıoğlu, 2019).

Table 7. The averages of days to physiological maturity of broad bean cultivars (day)

Çizelge 7. *Bakla çeşitlerinin fizyolojik olum gün sayısı özelliğine ait ortalamaları (gün)*

Cultivars	Farmyard Manure (kg ha^{-1})			Mean
	0	3000	6000	
Histal	**130.3**±0.08^{f}	134.0±0.58^{bc}	135.7±0.29^{a}	133.3^{B}
Salkim	131.7±0.63^{ef}	132.0±0.30^{de}	135.3±0.60^{ab}	133.0^{B}
Majör	133.3±0.58^{cd}	135.0±0.41^{ab}	135.0±0.72^{ab}	134.4^{A}
Gölyaka	132.3±0.08^{de}	**136.3**±0.38^{a}	135.7±0.50^{a}	134.8^{A}
Mean	131.9^{B}	134.3^{A}	135.4^{A}	133.9
LSD (Farmyard m.)=1.911				
LSD (Cultivar)=0.943				

Plant height was measured and the mean values (Table 8) were found between 39.0-55.7 cm. The factor of farmyard manure was significant in terms of this trait. It was observed that plant height increased as the doses of stable manure increased. The highest average plant height (54.3 cm) was measured at 6000 kg/ha dose. The plant height of Gölyaka is taller than the others. Cold days and snowfall during the vegetation period caused plant height to shorten and to be below the expected values. The cold tolerance range of broad bean can vary between -6ºC (summer sowing), -12ºC (winter varieties) (Landry et al., 2015). The developmental period and duration of the plant's exposure to cold are the most important factors determining this tolerance. In the study, temperatures below 0ºC in January, February and March caused shortening in plant height (Tablo 1) (Ece et al., 2004). In studies in which different broad bean genotypes were examined, plant height values varied between 63.63 and 125.33 cm (Pekşen and Gülümser 2006) and between 71.33 and 116.07 cm (Pekşen et al., 2006). Although a positive relationship between plant height and grain yield can be expected, in some studies, high plant height causes lodging of faba beans. Aldemir et al. (2019), also used farmyard manure as organic fertiliser in chickpea plants and measured that plant height varied between 38.9-44.2 cm.

Table 8. The averages of plant height of broad bean cultivars (cm)

***Çizelge 8**. Bakla çeşitlerinin bitki boyu özelliğine ait ortalamaları (cm)*

Cultivars	Farmyard Manure (kg ha^{-1})			Mean
	0	**3000**	**6000**	
Histal	40.3±3.10	46.5±1.04	50.3±1.94	45.7
Salkim	39.0±2.28	45.3±1.08	55.3±4.44	46.6
Majör	40.0±1.86	48.3±1.57	55.7±2.76	48.0
Gölyaka	44.3±2.09	54.0±1.91	56.0±1.62	51.4
Mean	**40.9^{c}**	48.5^{b}	**54.3^{a}**	47.9
LSD (Farmyard m.)=3.252				

The mean values of the first pod height (Table 9) were found between 9.7-12.5 cm. Barn manure was found to be statistically significant for this trait. As the dose of farmyard manure increased, the height of the first pod increased, but since the plant lengths were short, this increase was not significant in practice. The first pod height of Salkim (11.7cm) was found to be longer among the varieties. First pod height is important for ease of manual harvesting of fresh pods and mechanical harvesting of dry seeds. Also, the lowest pods may be contaminated with soil particles due to splashing of raindrops. Since the plant height was short in this study, the first pod height was also short. It has been reported that there is a relationship between plant height and first pod height (Temel,1999). In previous studies in which different broad bean genotypes were examined, it was observed that the average first pod height values varied between 13.75-21.67 cm (Pekşen & Artik 2006). In another study, it was determined that the first pod height values were between 13.8-14.9 cm in some broad bean varieties grown in Siirt province (Uçar et al., 2020).

Table 9. The averages of the first pod height trait of pod varieties (cm)

***Çizelge 9.** Bakla çeşitlerinin ilk bakla yüksekliği özelliğine ait ortalamaları (cm)*

Cultivars	Farmyard Manure (kg ha^{-1})			Mean
	0	3000	6000	
Histal	10.3±0.41	11.3±0.34	12.7±0.51	11.4
Salkim	10.7±0.08	12.0±2.17	12.3±0.96	11.7
Majör	10.3±0.30	10.6±1.34	12.3±0.82	11.1
Gölyaka	9.7±0.50	11.5±0.68	12.7±0.58	11.3
Mean	**10.3^{b}**	11.4^{ab}	**12.5^{a}**	11.4
LSD (Farmyard m.)= 1.3438				

The stems other than the main stem are called lateral branches and they are reported to be affected by environmental conditions (Toker, 2004). The number of lateral branches per plant varies between 2 and 4 and the difference between varieties is significant. The number of branches is mainly influenced by agronomic management practices, including plant density (Gezahegn et al., 2016). The number of lateral branches per plant can also differ based on the differences in the genotype (Sozen & Karadavut, 2016). In the study, the number of branches per plant was measured and the average values (Table 10) were found between 0.3-3.3. According to the mean values, the number of branches of Gölyaka variety (2.7) was higher than other varieties. In the studies in which different pod populations were analyzed, the average number of branches was measured between 3.97-6.17 and 3.38-5.27 (Pekşen & Artık 2006; Ece et al., 2004).

Table 10. The averages of the number of lateral branches (number) trait of broad bean cultivars

Çizelge 10. *Bakla çeşitlerinin bitki yan dal sayısı (adet) özelliğine ait ortalamaları*

Cultivars	Farmyard Manure (kg ha^{-1})			Mean
	0	3000	6000	
Histal	0.3±0.46	0.3±0.30	1.7±0.45	**0.8^{b}**
Salkim	0.3±0.36	1.0±0.08	1.0±0.29	**0.8^{b}**
Majör	1.3±0.22	1.7±0.90	1.0±0.28	1.3^{b}
Gölyaka	2.0±0.43	2.7±0.63	3.3±0.44	**2.7^{a}**
Mean	1.0	1.4	1.8	1.4
LSD (cultivar)=0.893				

The number of pods per plant was measured and the mean values (Table 11) ranged from 4.7 to 16. Significant factors were identified in terms of PN, including the interaction between farmyard manure and variety, farmyard manure and variety. Majör variety yielded the highest number of pods per plant (16) at 6000 kg/ha stable manure dose. As the doses of farmyard manure increased, the number of pods increased statistically significant. Among the varieties, Gölyaka stood out in terms of number of pods (14.6). There is a strong correlation exists between the number of pods, grain number and grain yield (Loss & Siddique, 1997). In a study on lentils, Koç et al. (2019) reported the number of pods per plant to ranged from 71.0 to 93.0.

Table 11. The averages of pod number in plant (number of pods) trait of broad bean cultivars

Çizelge 11. *Bakla çeşitlerinin bitkide bakla sayısı (adet) özelliğine ait ortalamaları*

Cultivars	Farmyard Manure (kg ha^{-1})			Mean
	0	3000	6000	
Histal	**4.7**±0.45^{h}	7.7±0.33^{fg}	9.3±0.14^{ef}	7.2^{B}
Salkim	6.3±0.45^{gh}	8.0±0.33^{fg}	10.3±0.14^{de}	8.2^{B}
Major	6.3±0.44^{gh}	15.3±0.57^{ab}	**16.0±1.31^{a}**	12.6^{A}
Gölyaka	11.7±0.44^{cd}	13.3±0.57^{bc}	15.7±1.02^{a}	13.6^{A}
Mean	7.3^{C}	11.1^{B}	12.8^{A}	10.4
LSD (Farmyard m.)=0.997				
LSD (Cultivar)=1.208				
LSD (Farmyard m.*cultivar) =2.094				

The number of grains per pod was measured and the mean values (Table 12) ranged from 3.7 to 11.0. Significant factors affecting this trait included the interaction between farmyard manure and variety, as well as farmyard manure and variety individually. The highest number of grains per pod (11) was observed in Gölyaka cultivar at a dose of 6000 kg/ha of farmyard manure. As the farmyard manure doses increased, the number of grains per pod also increased, with the highest value (7.7) obtained at a dose of 6000 kg/ha of farmyard manure. Statistically significant differences in the number of grains per pod were found among the varieties, with the highest number (8.9) observed in Gölyaka. The number of grains per pod can impact pod yield (Lopez-Bellido et al., 2003). Previous studies have shown that the number of grains per pod ranged from 2.7 to 3.5 in different pod varieties (Başdemir et al., 2020). Both genotype and environment influence this trait, but the genotype was found to have a greater effect in the studies (Newton, 1979).

Table 12. The averages of number of grains in pods (number) of broad bean cultivars

Çizelge 12. *Bakla çeşitlerinin baklada tane sayısı (adet) özelliğine ait ortalamaları*

Cultivars	Farmyard Manure (kg ha^{-1})			Mean
	0	3000	6000	
Histal	**3.7**±0.29^{h}	4.6±0.28^{g}	5.3±0.17^{fg}	4.5^{C}
Salkim	5.7±0.28^{ef}	5.7±0.45^{ef}	6.5±0.06^{de}	6.0^{B}
Major	5.7±0.29^{ef}	5.9±0.16D^{ef}	7.9±0.22^{c}	6.5^{B}
Gölyaka	6.7±0.28^{d}	9.1±0.31^{b}	**11.0**±0.36^{a}	8.9^{A}
Mean	5.4^{C}	6.3^{B}	7.7^{A}	6.5
LSD (Farmyard m.)= 0.645				
LSD (Cultivar) =0.536				
LSD (Farmyard m.*cultivar)=0.929				

In the study, hundred seed weight was measured and the mean values (Table 13) ranged between 97.8 and 133.3 g. In terms of 100-SW, the interaction between farmyard manure and variety, farmyard manure, variety were found to be significant. According to the interaction, Major variety stood out in terms of hundred grain weight (133.3 g) at a farmyard manure dose of 6000 kg/ha. The effect of farmyard manure doses on hundred grain weight was statistically significant, with the weight increasing as the doses increased. The differences between the varieties were also statistically significant, with the major variety yielding the highest 100 grain weight (126.7g). The lower number of grains in the major variety contributed to the increase in hundred grain weight. Grain weight and size may vary among varieties (Landry et al., 2015; Etemadi et al., 2017). Additionally, environmental factors during the growing period can influence hundred grain weight (Salih, 1989). Dry conditions during the grain filling period may lead to a decrease in grain weight. Optimal pod development occurs between 12-20°C (Lidon et al., 2001). In this study, the average temperatures of 14-16°C in April and May during the pod filling period resulted in a favorable grain filling period and an average hundred grain weight. Faba bean varieties are categorized as large-seeded (>1.0 g seed^{-1}), medium-seeded (0.5-1.0 g seed^{-1}), and small-seeded (<0.5 g seed^{-1}) (Etemadi et al., 2018). In the previous studies, it was reported that the average values of 100 grain weight of different varieties were found to be between 107.0 and 123.9 g. The hundred grain weight of the Salkım variety was lower than the other varieties (Öncan-Sümer et al., 2022). In another study, 100 grain weight values in pods were measured between 118.9-126.2 g (Uçar et al., 2020).

Table 13. The average of 100-seed weight (g) of broad bean cultivars

Çizelge 13. *Bakla çeşitlerinin yüz tane ağırlığı (g) özelliğine ait ortalamaları*

Cultivars	Farmyard Manure (kg ha^{-1})			Mean
	0	3000	6000	
Histal	**97.8**±3.47^{d}	122.4±0.46^{bc}	126.0±1.01^{abc}	115.4^{B}
Salkim	114.0±1.13^{d}	123.0±0.72^{bc}	129.9±3.80^{ab}	122.3^{B}
Majör	118.3±2.64^{c}	128.3±2.44^{ab}	**133.3**±5.68^{a}	126.7^{A}
Gölyaka	122.0±0.60B^{c}	126.0±2.37^{abc}	127.7±1.96^{ab}	125.2^{A}
Mean	113.0^{B}	124.9^{A}	129.2^{A}	122.4
LSD (Farmyard m.)=4.432				
LSD (Cultivar)=5.261				
LSD (Farmyard m.*cultivar)=9.114				

The average values of grain yield (Table 14) were between 1740.0 to 2836.0 kg/ha. Farmyard manure and variety factors were found to be significant for this trait. It was determined that the doses of stable manure increased the grain yield and the yield increased as the doses increased. The difference between the varieties was found to be statistically significant, with the Gölyaka variety (2414.0 kg/ha) standing out. Grain yield is influenced by both genotype and environmental factors. Previous studies have shown that the differences between varieties were found to be significant, and the average values varied between 1700-1831.0 kg/ha (Uçar et al., 2020; Pekşen & Artık, 2006; Karaköy et al., 2017; Başdemir et al., 2020). In a study conducted by Karayel (2020), grain yield and protein ratio values in grain were analysed by regression analysis considering the doses of farmyard manure and it was reported that fertilizer doses were secondarily important for grain yield, while protein ratio was primarily important. In a study examining grain yields of different broad bean populations, the yields were obtained between 1654.3 and 5892.3 kg/ha (Pekşen & Artık, 2006). Bozoglu et al. (2002) measured fresh broad bean yields between 7.73 and 9.15 tonnes/ha. However, it was observed that the genotype factor was not effective on grain yield in some green-consumed broad bean grains (Ece et al., 2004). The higher values of the number of grains in pods and the number of grains in the plant lead to an increase in grain yield (Sindhu, 1985). In previous studies, it was reported that fertilizer application significantly enhances grain yield (Fekadu et al., 2018). Aldemir et al. (2019) observed a higher grain yield from farmyard manure application compared to chemical fertilizer application in chickpeas. In the study of compost and farmyard manure application in beans, the effects of dry matter content and yield were found to be statistically significant (Yağmur et al., 2017). Saylak (2018) found grain yield in pods as 2444.0 kg/ha in his study. Previous studies have shown that farmyard manure application increases grain yield (Sabourifard et al., 2023).

Table 14. Averages of grain yield (kg/ha) trait of broad bean varieties

Çizelge 14. *Bakla çeşitlerinin tane verimi (kg/ha) özelliğine ait ortalamaları*

Cultivars	Farmyard Manure (kg ha^{-1})			Mean
	0	3000	6000	
Histal	**1740.0**±4.30	1870.0±9.32	2470.0±10.32	2027.0^{b}
Salkim	1780.0±3.21	1837.0±10.63	2430.0±7.09	2020.0^{b}
Major	1910.0±2.77	2300.0±12.67	**2836.0**±9.18	2348.0^{a}
Gölyaka	2123.0±2.85	2285.0±3.25	2833.0±12.43	2414.0^{a}
Mean	1892.0^{c}	2073.0^{b}	2642.0^{a}	2202.0
LSD (Farmyard m.)= 107.04				
LSD (Cultivar)=162.50				

In this study, grain protein ratio was measured, and the mean values (Table 15) were found between 20.8 and 23.7. The cultivar factors were found to be significant in terms of this trait. The differences between the varieties were found statistically significant. The highest grain protein ratio (23,5) was obtained from Histal variety. The differences between farmyard manure*variety interaction and farmyard manure factor were found statistically insignificant. In the studies (Karayel et al., 2020), the highest seed protein ratio was obtained from 3000 kg/ha farmyard manure dose application. Aldemir et al. (2019) reported protein ratios ranging from 22.67% to 25.67% in their study on chickpeas, which included organic fertilizer application with farmyard manure. Öncan Sümer et al. (2022) indicated that phosphorus doses influenced the seed protein ratio, with the highest values obtained from a 12 kg/da phosphorus dose, resulting in a grain protein ratio of 24.7% in the first year and 25.3% in the second year.

Table 15. The averages of grain protein (%) trait of broad bean cultivars

Çizelge 15. *Bakla çeşitlerinin tane protein (%) özelliğine ait ortalamaları*

Cultivars	Farmyard Manure (kg ha^{-1})			Mean
	0	3000	6000	
Histal	22.6±0.27	23.4±0.49	23.5±0.31	**23.1^{a}**
Salkim	20.9±0.54	22.1±0.08	21.7±0.34	21.2^{b}
Major	21.0±0.51	21.2±0.07	21.5±0.14	21.3^{b}
Gölyaka	20.7±0.18	21.3±0.47	21.1±0.11	**21.0^{b}**
Mean	21.3	21.7	22.0	21.7
LSD (Cultivar)= 0.924				

CONCLUSION

According to the results of the study, the application of farmyard manure had a positive effect on many traits examined, and grain yield and yield components increased as the dose increased. In the year of the study, it was observed that the plants had a short stature, and yield components were adversely affected by low temperatures due to the snowfall during the vegetation period when the pods had 5-6 leaves and low temperatures in winter months. In terms of grain yield, Gölyaka and Major showed higher yields compared to the others. The literature reports that the positive effect of farmyard manure application on soil physical properties and microorganism activities can be observed several years after application. However, it is crucial to continue the study to observe the positive effects on plant yield and yield characteristics. Evaluating multi-year data together will provide clearer results. Additionally, higher doses can be included in the study to observe the effect of farmyard manure more distinctly.

Data Availability

Data will be made available upon reasonable request.

Author Contributions

Conception and design of the study: FÖS, SÖS; sample collection: SÖS; analysis and interpretation of data: FÖS; statistical analysis: FÖS, SÖS; visualization: FÖS, SÖS; writing manuscript: FÖS, SÖS.

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.

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