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Research Article

The Effects of Different Fertilizer Applications on Some Morphological Traits in Fresh Bean

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Abstract: The study was conducted to determine the morphological changes caused by different fertilizer applications on the fresh bean, in the Göllü Village of Tusba District of Van Province according to the randomized blocks experimental design in 2019 and 2020. Sazova 1949 dwarf bean variety was used as plant material in the study. The field experiment was carried out with 4 replications and 4 different fertilizer applications (chemical, organomineral, cattle, and vermicompost) except for the control. In the study, plant height, stem diameter, node number, internode length, flower bud length, flower bud width, flower stem length, number of flowers per cluster, bract length, number of nodes with the first flower, middle leaflet length, number of leaves, first pod height, pod length, pod width, number of pods per bunch, pod weight, pod thickness, number of seeds per pod, chlorophyll (SPAD value) and leaf color L*, a*, b, Chroma°, and hue° values were investigated. As a result of the study; it was determined that different fertilizer applications gave significantly different results in terms of the traits examined, higher results were obtained from organomineral and vermicompost fertilizers compared to the control group, and generally equivalent or better results were obtained than chemical fertilizers. It was concluded that some organic fertilizer applications in bean cultivation might be used as an alternative to chemical fertilizer applications in terms of a sustainable world.

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1. Introduction

Beans (*Phaseolus vulgaris* L.) (2n = 22) are among the predominantly self-pollinated legume group vegetables (Ferreira et al., 2000). The domesticated bean had multiple origins in the New World and is one of the oldest cultivated plants (Beebe et al., 2013). Bean, which has an important place in terms of agricultural production, also has an important place in human nutrition because it contains protein, vitamins, minerals, complex carbohydrates, and micronutrients (Ekincialp and Şensoy, 2018). Because beans are evaluated in many ways such as fresh, canned, pickled, and dried, it is very valuable to know the effects of quality-enhancing practices in agriculture.

It is important that the practices carried out do not harm human health, guarantee long-term income for the producer, protect the ecological system and biodiversity, and aim to leave better quality and efficient products to future generations. In this context, the importance of sustainable agricultural practices is increasing day by day. The concept of sustainable agriculture is an approach that aims to balance agronomic, environmental, social, and economic dimensions in agricultural production. Its aim is to keep the economy alive in the short and long term, to increase the quality of life of those engaged in agriculture and to develop practices for this purpose, while maintaining productivity in agriculture on the one hand, reducing the damage to the environment on the other hand (Turhan, 2005). Considering the nutritional value of organic agricultural products included in sustainable agriculture, they may contain more vitamins and mineral matters in addition to containing less nitrate and heavy metals than conventional agricultural products (Girgel et al., 2018). It has been reported that inorganic fertilization causes nitrate accumulation three times more in lettuce and salad compared to organic fertilizer (Özgen et al., 2011). Organic fertilizers, which are the main inputs of organic farming systems that have become widespread with people's interest in organic products, are offered to the use of producers under various names and contents in the market (Okur et al., 2007). Among these fertilizers, vermicompost, farmyard, sheep, cattle, poultry manure, and organic fertilizer-reinforced chemical fertilizers are the most commonly used fertilizers, and different effects on the growth and development of many plant species have been examined in different studies by different researchers (Şensoy et al., 1996; Toy, 2015; Yeşilbaş 2015; Tunçtürk et al., 2016; Dumlupınar, 2017; Ata, 2018; Kabay et al., 2018; Müjdeci et al., 2020). The idea that yield-oriented wrong fertilizer applications in the production of vegetable species that have an important place in human nutrition damage the ecological system and that biodiversity is gradually disappearing has awakened the awareness that the natural balance should be regained all over the world.

Therefore, studies to ensure the sustainability of the ecological system and to protect biodiversity have great importance. In this study, it was aimed to determine the effects of some organic and conventional fertilizer applications on some morphological properties of fresh bean and to determine the fertilizers that can be an alternative to chemical fertilizers.

2. Materials and Methods

In the present study, the dwarf standard fresh bean variety Sazova 1949, which was obtained from the original seed, whose field and laboratory controls were made by the Geçitkuşağı Agricultural Research Institute, was used as the bean variety in the study. Morphological measurements were used to determine the difference between organic and conventional fertilizer applications in fresh bean cultivation. The experiment was established in the village of Göllü with latitude 38.7202 and longitude 43.3124 coordinates within the borders of Tuşba district of Van for 2 years, according to the randomized blocks experimental design with 4 replications and 4 different fertilizer applications except for the control. Total of 6 kg N, 7 kg P_2O_5, and 8 kg K_2O were applied as fertilizer per decare. The 6 kg of N:P:K per decare was given as the compound fertilizer of 18:18:18 (NPK). The rest of the phosphorus and potassium were completed as triple superphosphate and potassium sulfate, respectively. For other fertilizers, 54.50 kg organomineral fertilizer, 300 kg vermicompost and cattle manure per decare in 2019, 54.56 kg organomineral fertilizer, 290 kg vermicompost and 923 kg cattle manure per decare were applied to the parcels in 2020, approximately equivalent to chemical fertilizers. The distances between the plots were 2 m, the row spacing within the plot was 25 cm, and the intra-row spacing was 50 cm, and the size of each plot corresponded to 4m x 3.5m. The side effect was applied to the plots and there were a total of 112 plants from each plot, and 80 plants in the middle of these were used for analysis, measurement, and observations. The irrigation process in the plots was carried out by drip irrigation method.

2.1. Morphological traits

IPGRI (International Plant Genetic Resources Institute) and EU CPVO (European Community Plant Variety Office) data (Anonim, 2009) and some agronomic traits included in the technical instruction of the Ministry of Agriculture Turkey for the measurement of agricultural values were used for morphological observations (Erdinç et al., 2013). Moreover, the necessary measurements were made on 10 randomly selected plants and pods in each plot. All the morphological traits used are listed below.

Plant height (cm) (at physiological maturity): It was measured from the root crown to the tip of the stem with the help of a meter.
Stem diameter (mm): The stem diameter was measured with the help of digital caliper.
The number of nodes on the stem at physiological maturity: It was determined by counting the nodes on the main stem.
Internode length (mm): Nodes located in the middle of the main stem were measured with the help of a digital caliper.
Flower bud length (mm): It was measured with the help of a digital caliper during 50% flowering.
Flower bud width (mm): It was measured with the help of a digital caliper during 50% flowering.
Flower stem length (mm): It was measured with the help of a digital caliper at 50% flowering.
The number of flower buds per cluster: The flower buds on the first cluster were counted.
Bract length (mm): It was measured with the help of a digital caliper.
The number of nodes with the first flower: The node with the first flower was determined by counting.
The length of the middle leaflet (mm): It was measured with the help of a digital caliper.
The average number of leaves per plant: The leaves over the 1 plant were determined by counting total in 10 plants.
First pod height (cm): The height of the first pod to the soil surface was determined with the help of a digital caliper.
Pod length (mm): Measured with the help of a digital caliper.
Pod width (mm): Measured with the help of a digital caliper.
The number of pods per bunch: The pods in the bunch were determined by counting.
Average pod weight (g): The weight of each harvested pod was determined with the help of precision scales by taking the average of 10 plants.
Pod thickness (mm): It was measured with the help of a digital caliper.
The number of seeds per pod (piece): The seeds in the pods were measured by shelling.
Leaf chlorophyll content (SPAD value): It was determined with the help of an SPAD meter (Minolta SPAD-502, Osaka, Japan).
Leaf color (L, a*, b, Chroma° and hue°):* Determined by a Colorimeter (CR-400 Minolta).

2.2. Statistical analysis

The data obtained in the study were evaluated according to the degree of significance with one-way analysis of variance according to the randomized blocks experimental design. Means that were found to be statistically significant in the analysis of the data were grouped according to the "Duncan Multiple Comparison Test". Descriptive statistics were expressed as mean and standard error. The statistical significance level was taken as 5% in the calculations. The “SPSS version 20.0” statistical package program was used for the calculations.

3. Results and Discussion

In the present study, plant height, stem diameter, number of node, internode length, flower bud length, flower bud width, flower stem length, number of flower buds per cluster, bract length, number of nodes with first flower, middle leaflet length, number of leaves, first pod height, pod length, pod width, number of pods per bunch, pod weight, pod thickness, number of seeds per pod, chlorophyll (SPAD) and leaf color L*, a*, b, Chroma°, and hue° values were investigated (Table 1-7).

When the obtained values are analyzed statistically; The difference among the fertilizers was found to be significant in terms of plant height both in 2019 and in years average (Table 1). For plant height; it was also observed that there was a difference between years in terms of organomineral and vermicompost fertilizers. In the values obtained from the stem diameter; in terms of organomineral fertilizer, the difference between years was significant. In the data obtained from the number of nodes, the difference between fertilizers for both 2019 and 2020 was found to be significant. For the internode lengths; while the difference between fertilizers was found to be significant in 2019, the difference between years was determined to be significant in all applications. Çiftçi and Şehrali (1984) reported that plant height in bean varies between 17.0-164.0 depending on the variety and environmental conditions. In a study investigating the effects of sowing dates and potassium fertilizer rates on bean yield, it was reported that plant height, stem diameter, and potassium content increased with potassium application (Badawy et al., 2019). In a study conducted for the performance evaluation of fresh bean genotypes for yield and related traits, it was reported that stem diameter values ranged between 3.00-5.70 cm (Yohannes et al., 2020). Sepetoğlu (1992) stated that the number of nodes in dwarf bean cultivars is 3 to 10 per plant, and they reported that this difference may vary depending on genetic structure and growing conditions. In another study conducted in Southern Ethiopia for the performance evaluation of fresh bean genotypes for yield and related traits, internode length values were reported to vary between 4.00 to 7.00 cm (Yohannes et al., 2020).

Table 1. The effects of fertilizers on plant height (cm), stem diameter (mm), number of node and internode length (mm)

2019	Plant height	Stem diameter	Number of nodes	Internode length
Control	36.84 ± 1.80d	7.15 ± 0.24	5.03 ± 0.28 b	63.48 ± 4.69 ab B
Chemical	42.53 ± 1.40 bc	7.56 ± 0.24	5.35 ± 0.19 b	58.34 ± 0.76 b B
Organomineral	49.11 ± 1.15 a A	7.49 ± 0.15 B	6.49 ± 0.43 a	72.10 ± 3.62 a B
Cattle manure	39.79 ± 2.03 cd	7.58 ± 0.42	4.88 ± 0.18 b	62.73 ± 4.85 ab B
Vermicompost	47.30 ± 1.74 ab A	7.28 ± 0.25	5.90 ± 0.42 ab	61.94 ± 1.41 ab B
Mean	43.11 ± 1.24	7.41 ± 0.12	5.53 ± 0.19	63.72 ± 1.74
$p_{fertilizer}$	0.001	0.748	0.015	0.131
2020				
Control	36.10 ± 3.07	7.83 ± 0.25	3.50 ± 0.17 b	75.20 ± 0.53 A
Chemical	41.70 ± 1.12	8.07 ± 0.28	4.15 ± 0.21 a	76.14 ± 0.64 A
Organomineral	38.65 ± 0.64 B	8.36 ± 0.20 A	4.15 ± 0.24 a	77.00 ± 0.88 A
Cattle manure	41.70 ± 1.37	8.08 ± 0.20	4.05 ± 0.10 ab	77.02 ± 0.26 A
Vermicompost	39.90 ± 2.14 B	8.00 ± 0.34	4.00 ± 0.22 ab	75.53 ± 0.51 A
Mean	39.61 ± 0.89	8.07 ± 0.11	3.97 ± 0.09	76.18 ± 0.29
$p_{fertilizer}$	0.232	0.705	0.148	0.162
		Years average		
Control	36.47 ± 1.65 b	7.48 ± 0.20	4.26 ± 0.32	69.34 ± 3.11
Chemical	42.11 ± 0.84 a	7.81 ± 0.19	4.75 ± 0.26	67.24 ± 3.39
Organomineral	43.88 ± 2.06 a	7.92 ± 0.19	5.31 ± 0.49	74.54 ± 1.95
Cattle manure	40.74 ± 1.19 ab	7.82 ± 0.23	4.26 ± 0.18	69.87 ± 3.51
Vermicompost	43.60 ± 1.89 a	7.64 ± 0.23	4.95 ± 0.42	68.73 ± 2.66
$p_{fertilizer}$	0.015	0.633	0.269	0.503

Small letters show the difference among the applications for the same year and years average. Capital letters show the difference between the years for the same application and parameter ($p<0.05$). Data are expressed as ± standard error.

When the obtained values are analyzed; it was observed that there was a difference between years in terms of all fertilizer applications for flower bud length (Table 2). In the data on flower bud width; it was observed that there was a difference between years in terms of organomineral fertilizer, cattle manure, and vermicompost applications. In the number of flower buds per cluster; It was observed that there was a difference between years only in terms of the control group. Karahan (1997), in a study in which the effects of bacterial inoculation and five nitrogen doses in dwarf bean cultivars in Thrace conditions were determined; reported that the number of flowers in the cluster varies between 3.1 and 6.2. In another study, it has been reported that the flower bud length is 8.51-17.05 mm, the flower bud width is 3.04-5.51 mm, the flower stem length is 2.72-10.35 mm, and the number of flower buds in a cluster varies between 1.20 and 10.40 (Erdinç et al., 2013).

When the obtained values are analyzed; The difference between the fertilizers was found to be significant in terms of both the year 2020 and the average of years in terms of bract length (Table 3). In addition, for the bracket length; it was observed that there was a difference between years in terms of cattle manure. For the number of nodes with the first flower; the difference between fertilizers was found to be significant in terms of both the year 2019 and the average of the years. In the data obtained from the length of the middle leaflet; the difference between fertilizers was found to be significant for both 2019 and year averages. In the values of the number of leaves; the difference between years was determined to be significant in all applications. It was stated that plant height, number of branches, number of leaves, and number of fruits are important factors affecting yield in beans (Ayanoğlu et al., 1995). In a study carried out to determine the flower and seed characteristics of various bean (*Phaseolus vulgaris* L.) genotypes, the length of the bract was 3.98-6.19 mm in the first year, the number of nodes with the first flower was 3.50-7.50; In the second year, it was determined that the length of the bract varies between 4.31-7.07 mm and the number of nodes with the first flower varies between 2.67-7.17 (Çiftçi et al., 2012). In another study, the bract size is 3.64-8.10 mm, the number of nodes with the first flower is 1.75-7.0, the length of the middle leaflet is 55.21-120.39 mm, and the presence of leaves at physiological maturity varies between 1 and 7 (Erdinç et al., 2013). In a study carried out to determine the effects of vermicompost and mycorrhiza use on plant growth and yield in beans and onions, when the values of the number of leaves were examined, it was found that for beans it varied between 5.66 and7.00, the highest result was found in vermicompost application (7.00), and the lowest value was obtained in the application of vermicompost fertilizer + mycorrhiza (5.66) (Uluğ, 2018).

Table 2. The effects of fertilizers on flower bud length (mm), flower bud width (mm), flower stem length (mm) and number of flower buds per cluster

2019	Flower bud length	Flower bud width	Flower stem length	Number of flower buds per cluster
Control	8.04 ± 0.38 B	4.10 ± 0.21	3.70 ± 0.06	3.15 ± 0,15 B
Chemical	7.80 ± 0.33 B	4.43 ± 0.17	3.93 ± 0.11	3.22 ± 0.27
Organomineral	8.04 ± 0.54 B	4.21 ± 0.14 B	3.91 ± 0.21	4.15 ± 0.41
Cattle manure	7.78 ± 0.21 B	4.30 ± 0.07 B	4.03 ± 0.19	3.55 ± 0.31
Vermicompost	7.71 ± 0.35 B	4.35 ± 0.07 B	4.08 ± 0.25	3.97 ± 0.22
Mean	7.87 ± 0.15	4.28 ± 0.06	3.93 ± 0.08	3.61±0.14
$p_{fertilizer}$	0.949	0.545	0.608	0.101
2020				
Control	11.10 ± 0.99 A	4.97 ± 0.54	3.96 ± 0.10	3.40 ± 0.40 A
Chemical	13.09 ± 0.60 A	5.49 ± 0.43	4.20 ± 0.16	3.50 ± 0.13
Organomineral	12.85 ± 0.86 A	6.00 ± 0.47 A	4.36 ± 0.21	3.45 ± 0.50
Cattle manure	12.70 ± 0.51 A	5.97 ± 0.31 A	4.48 ± 0.09	3.50 ± 0.31
Vermicompost	12.39 ± 0.41 A	5.87 ± 0.39 A	4.40 ± 0.13	3.75 ± 0.15
Mean	12.43 ± 0.32	5.66 ± 0.19	4.28 ± 0.07	3.52 ± 0.13
$p_{fertilizer}$	0.339	0.438	0.161	0.952
Years average				
Control	9.57 ± 0.76	4.54 ± 0.31	3.83 ± 0.07	3.28 ± 0.20
Chemical	10.44 ± 1.05	4.96 ± 0.29	4.07 ± 0.11	3.36 ± 0.15
Organomineral	10.44 ± 1.02	5.11 ± 0.41	4.13 ± 0.16	3.80 ± 0.33
Cattle manure	10.24 ± 0.96	5.13 ± 0.35	4.25 ± 0.13	3.53 ± 0.20
Vermicompost	10.05 ± 0.92	5.11 ± 0.34	4.24 ± 0.14	3.86 ± 0.13
$p_{fertilizer}$	0.963	0.711	0.621	0.234

Small letters show the difference among the applications for the same year and years average. Capital letters show the difference between the years for the same application and parameter ($p<0.05$). Data are expressed as ± standard error.

Table 3. The effects of fertilizers on bract length (mm), number of nodes with first flower, middle leaflet length (mm) and number of leaves

2019	Bract length	Number of nodes with first flower	Middle leaflet length	Number of leaves
Control	3.70 ± 0.05	1.33 ± 0.06b	78.25 ± 1.21c B	16.23 ± 0.95 B
Chemical	3.93 ± 0.11	1.40 ± 0.06b	92.27 ± 1.10ab	16.33 ± 1.27 B
Organomineral	3.90 ± 0.20	1.83 ± 0.09a	88.94 ± 2.24b	16.25 ± 0.65 B
Cattle manure	4.02 ± 0.19 B	1.55 ± 0.15ab	87.99 ± 1.15b	16.30 ± 0.66 B
Vermicompost	4.08 ± 0.24	1.60 ± 0.04ab	93.82 ± 1.22a	16.70 ± 0.92 B
Mean	3.92 ± 0.07	1.54 ± 0.05	88.25 ± 1.37	16.36 ± 0.37
$p_{fertilizer}$	0.608	0.010	0.001	0.996
2020				
Control	3.96 ± 0.10 b	1.45 ± 0.10	88.36 ± 1.17 A	20.70 ± 1.24 A
Chemical	4.20 ± 0.16 ab	1.30 ± 0.06	94.37 ± 2.00	22.50 ± 0.79 A
Organomineral	4.36 ± 0.21 ab	1.50 ± 0.24	94.14 ± 4.83	22.95 ± 0.87 A
Cattle manure	4.47 ± 0.09 a A	1.70 ± 0.13	93.45 ± 3.36	22.25 ± 0.85 A
Vermicompost	4.40 ± 0.13 ab	1.60 ± 0.12	91.72 ± 3.41	21.95 ± 0.98 A
Mean	4.28 ± 0.07	1.51 ± 0.06	92.41 ± 1.38	22.07 ± 0.42
$p_{fertilizer}$	0.161	0.367	0.668	0.552
Years average				
Control	3.83 ± 0.7b	1.39 ± 0.06bc	83.30 ± 2.06b	18.46 ± 1.11
Chemical	4.06 ± 0.10ab	1.35 ± 0.04c	93.32 ± 1.13a	19.41 ± 1.36
Organomineral	4.13 ± 0.16ab	1.66 ± 0.13a	91.54 ± 2.65a	19.60 ± 1.36
Cattle manure	4.25 ± 0.13a	1.63 ± 0.10ab	90.72 ± 1.94a	19.28 ± 1.23
Vermicompost	4.24 ± 0.14a	1.60 ± 0.06bc	92.77 ± 1.72a	19.33 ± 1.17
$p_{fertilizer}$	0.146	0.031	0.006	0.973

Small letters show the difference among the applications for the same year and years average. Capital letters show the difference between the years for the same application and parameter ($p<0.05$). Data are expressed as ± standard error.

When the obtained data are analyzed; the difference between years in terms of the first pod height was found to be significant in all applications (Table 4). The difference between the applications was found to be significant for both the years and the average of the years in the values of the pod length. In addition, the difference between years was found to be significant for the control group for pod length, and for chemical and organomineral fertilizers. In the data obtained from the width of the pod; For 2020, the difference between fertilizers and between years for all applications was found to be significant. In bean cultivation, pod characteristics have an important place and there can be great differences between varieties (Gündüz et al., 2000; Balkaya and Odabas, 2002). It has been determined that the variety, cultivation technique (such as sowing density, fertilization, etc.) and environmental conditions have a significant effect on the height of the first pod (Önder and Şentürk, 1996). It was emphasized that the first pod height, one of the parameters examined in the study, is the most important criterion for mechanical harvesting in beans (Odabaş and Gülümser, 2001). In a study investigating the effects of different nitrogen-based fertilizers on yield and yield components in beans, the researchers stated that fertilizer doses increased the first pod height and length. In a study investigating the effects of different boron doses applied from leaves and soil on yield and yield components in bean, it was determined that increasing fertilizer doses caused an increase in the first pod height compared to the control group, and the highest value was 22.13 cm at 1.5 kg ha^{-1} boron application (Gülümser et al., 2005). In a study carried out to determine the effects of vermicompost and mycorrhiza use on plant growth and yield in beans and onions, when the pod length and width values were examined, it was found that the pod length in beans varied between 10.89 cm and 12.76 cm, and the pod width ranged between 12.82 mm and 15.07 mm, and the highest results were obtained with vermicompost (Uluğ, 2018). In a study conducted to determine the yield and some quality factors of some dwarf fresh bean cultivars in Konya conditions, it was determined that the average pod length varies between 128.7 mm and 146.2 mm and the average pod width varies between 13.9 mm and 15.3 mm (Seymen et al., 2010).

Table 4. The effects of fertilizers on first pod height (cm), pod length (mm) and pod width (mm)

2019	First pod height	Pod length	Pod width
Control	7.93 ± 0.55 A	121.00 ± 2.27ab A	9.78 ± 0.25 B
Chemical	7.53 ± 0.34 B	126.00 ± 2.74ab A	10.09 ± 0.17 B
Organomineral	8.42 ± 0.38 A	130.00 ± 2.92a A	10.09 ± 0.28 B
Cattle manure	8.41 ± 0.34 B	117.50 ± 4.56b	9.66 ± 0.20 B
Vermicompost	7.86 ± 0.43 B	121.25 ± 1.65ab	9.87 ± 0.17 B
Mean	8.03± 0.18	123.15 ± 1.55	9.90 ± 0.09
$p_{fertilizer}$	0.516	0.073	0.544
2020			
Control	7.50 ± 0.52 B	109.37 ± 1.47c B	11.26 ± 0.11b A
Chemical	8.75 ± 0.63 A	113.87 ± 2.32bc B	11.47 ± 0.28ab A
Organomineral	8.15 ± 0.73 B	114.72 ± 0.84bc B	11.57 ± 0.01ab A
Cattle manure	8.55 ± 0.43 A	119.55 ± 0.41b	11.42 ± 0.28ab A
Vermicompost	8.40 ± 0.39 A	127.98 ± 3.58a	12.10 ± 0.23a A
Mean	8.27 ± 0.24	117.10 ± 1.67	11.56 ± 0.11
$p_{fertilizer}$	0.566	0.001	0.112
Years average			
Control	7.71 ± 0.36	115.19 ± 2.53b	10.52 ± 0.31
Chemical	8.14 ± 0.39	119.93 ± 2.83ab	10.78 ± 0.30
Organomineral	8.29 ± 0.38	122.36 ± 3.21ab	10.83 ± 0.31
Cattle manure	8.48 ± 0.26	118.53 ± 2.15ab	10.54 ± 0.37
Vermicompost	8.13 ± 0.29	124.61 ± 2.22a	10.98 ± 0.44
$p_{fertilizer}$	0.613	0.131	0.861

Small letters show the difference among the applications for the same year and years average. Capital letters show the difference between the years for the same application and parameter ($p<0.05$). Data are expressed as ± standard error.

When the data is analyzed; the difference between fertilizers in the number of pods in a bunch was found to be significant in 2019 (Table 5). In terms of pod weight; while the difference between fertilizers was found to be significant for 2020, it was observed that the difference between years was significant in all applications. The difference between fertilizers was found to be significant in terms of pod thickness in 2020. In addition, in the thickness of the pod; the difference between years was found to be significant in chemical and cattle manure. The difference among the fertilizer was found to be significant in terms of the number of seeds in the pod in 2020. In addition, the number of seeds in the pod; The difference between years was found significant in control group, chemical, and cattle manure fertilizer. In a study carried out to determine the effects of vermicompost and mycorrhiza use on plant growth and yield in beans and onions, when the values of the pod weight and the number of seeds in the pod were examined, the weight of the pod in bean varied between 5.84 g and 8.94 g, the number of seeds in the pod varied between 4.87 and 5.71 and it was determined that the highest pod weight and the number of seeds in the pod were in the application of vermicompost (Uluğ, 2018). In a study carried out to determine the yield and some quality factors of some dwarf fresh bean cultivars in Konya conditions, the average number of pods per plant was between 13.5 and 33.4, the pod thickness was between 6.7 mm and 7.9 mm, the number of seeds per pod ranged from 6.7 to 7.5 and it was determined that there were significant differences among them (Seymen et al., 2010).

Table 5. The effects of fertilizers on the number of pods per bunch (piece), pod weight (g), pod thickness (mm) and number of seeds per pod (piece).

2019	Number of pods per bunch	Pod weight (g)		Pod thickness (mm)		Number of seeds per pod	
Control	3.15 ± 0.15b	5.65 ± 0.22	B	2.61 ± 0.25		6.00 ± 0.00ab	B
Chemical	3.22 ± 0.27ab	6.27 ± 0.24	B	2.78 ± 0.10	B	6.25 ± 0.25ab	B
Organomineral	4.15 ± 0.41a	5.90 ± 0.52	B	2.95 ± 0.07		6.75 ± 0.25a	
Cattle manure	3.55 ± 0.31ab	5.90 ± 0.50	B	2.57 ± 0.25	B	5.50 ± 0.29b	B
Vermicompost	3.97 ± 0.22ab	5.65 ± 0.14	B	2.90 ± 0.12		6.50 ± 0.50a	
Mean	3.61 ± 0.14	5.87 ± 0.15		2.76 ± 0.08		6.20 ± 0.16	
$p_{fertilizer}$	0.101	0.728		0.461		0.085	
2020							
Control	3.40 ± 0.40	7.19 ± 0.10c	A	2.75 ± 0.20b		6.70 ± 0.13b	A
Chemical	3.50 ± 0.12	8.03 ± 0.04a	A	3.05 ± 0.07ab	A	7.20 ± 0.14a	A
Organomineral	3.45 ± 0.49	8.01 ± 0.08a	A	2.89 ± 0.12ab		7.25 ± 0.22a	
Cattle manure	3.50 ± 0.31	7.52 ± 0.09b	A	3.19 ± 0.10a	A	7.15 ± 0.10ab	A
Vermicompost	3.75 ± 0.15	7.69 ± 0.09b	A	3.18 ± 0.06a		7.40 ± 0.14a	
Mean	3.52 ± 0.13	7.69 ± 0.08		3.01 ± 0.06		7.14 ± 0.08	
$p_{fertilizer}$	0.952	0.001		0.087		0.052	
		Years average					
Control	3.27 ± 0.20	6.42 ± 0.31		2.68 ± 0.15		6.35 ± 0.15	
Chemical	3.36 ± 0.15	7.15 ± 0.35		2.91 ± 0.08		6.73 ± 0.22	
Organomineral	3.80 ± 0.32	6.96 ± 0.47		2.92 ± 0.06		7.00 ± 0.18	
Cattle manure	3.52 ± 0.20	6.71 ± 0.38		2.88 ± 0.17		6.33 ± 0.34	
Vermicompost	3.86 ± 0.13	6.67 ± 0.39		3.04 ± 0.08		6.95 ± 0.29	
$p_{fertilizer}$	0.234	0.710		0.299		0.178	

Small letters show the difference among the applications for the same year and years average. Capital letters show the difference between the years for the same application and parameter ($p<0.05$). Data are expressed as ± standard error.

When the data were analyzed, the difference between fertilizers for chlorophyll (SPAD value) in 2019 and 2020 was found to be significant (Table 6). In addition, the difference between years for SPAD value was found to be significant in all applications. In the data of leaf color L* values, the difference between applications for 2020 was found to be significant. The difference between years was also found to be significant for leaf color L* in terms of the control group, organomineral, and vermicompost. In the data obtained from the leaf color a* parameter; the difference between fertilizers and between years for all applications was found to be significant in 2020. In a study investigating the effect of different nitrogen sources at different doses on the yield and amount of chlorophyll in the leaf; It has been reported that increasing doses of fertilizers affect the chlorophyll a and b content (Odabaş and Gülümser, 2001). Abou El-Yazied (2011) reported that the average leaf chlorophyll content varied between 35.4 and 46.4 SPAD values in another study in which the effects of leaf chlorophyll content on bean growth, biochemical components, physiological parameters, and yield were determined. The L* value determines the light-darkness coordinates of the color (Çavuşoğlu and Gökçenay, 2018). The a* value from the color parameters expresses the color changes from red (positive) to green (negative) (Kibar et al., 2020). In a study in which the morphological characteristics of some fresh bean cultivar candidates and commercial cultivars were determined, it was reported that the leaf color varies between light green and very dark green (Balkaya and Yanmaz, 2003). It has been reported that the L* and a* values of boron applications at different times were higher than the control, the leaf color L* value varied between 35.38 and 52.90, and the leaf color a* value varied between (-1.93) and (-11.92) values in the bean genotypes (Akoğlu, 2013). In a study in which the effects of salt and putrescine applications on germination and seedling growth in beans were determined, the leaf color L* value varied between 39.15 and 41.92, and the leaf color a* value varied between (-8.60) and (-11.74) (Kibar et al., 2020).

Table 6. The effects of fertilizers on chlorophyll (SPAD value), and leaf color values, (L*) and (a*)

2019	**SPAD**		**L***		**a***	
Control	31.46 ± 0.58b	B	45.74 ± 0.46	A	-15.48 ± 0.12	B
Chemical	33.46 ± 0.30a	B	44.62 ± 2.10		-15.78 ± 0.43	B
Organomineral	32.45 ± 0.60ab	B	44.44 ± 1.56	A	-15.73 ± 0.35	B
Cattle manure	32.81 ± 0.44ab	B	44.43 ± 0.80		-15.63 ± 0.22	B
Vermicompost	32.46 ± 0.41ab	B	43.97 ± 0.61	A	-14.98 ± 0.27	B
Mean	32.53 ± 0.24		44.64 ± 0.52		-15.52 ± 0.14	
$p_{fertilizer}$	0.110		0.892		0.359	
2020						
Control	37.84 ± 2.15b	A	40.31 ± 0.29b	B	-11.69 ± 0.63a	A
Chemical	39.92 ± 0.30b	A	41.10 ± 0.77b		-12.17 ± 0.34ab	A
Organomineral	44.45 ± 0.23a	A	41.04 ± 0.43b	B	-12.70 ± 0.37ab	A
Cattle manure	41.03 ± 0.28ab	A	43.08 ± 0.90a		-14.25 ± 0.24c	A
Vermicompost	40.94 ± 1.80ab	A	40.98 ± 0.52b	B	-13.22 ± 0.22bc	A
Mean	40.83 ± 0.70		41.30 ± 0.33		-12.80 ± 0.26	
$p_{fertilizer}$	0.032		0.063		0.003	
			Years average			
Control	34.65 ± 1.59		43.03 ± 1.06		-13.58 ± 0.77	
Chemical	36.69 ± 1.24		42.86 ± 1.23		-13.97 ± 0.73	
Organomineral	38.45 ± 2.29		42.74 ± 0.99		-14.22 ± 0.62	
Cattle manure	36.92 ± 1.57		43.75 ± 0.61		-14.94 ± 0.30	
Vermicompost	36.70 ± 1.81		42.48 ± 0.67		-14.10 ± 0.37	
$p_{fertilizer}$	0.661		0.901		0.592	

Small letters show the difference among the applications for the same year and years average. Capital letters show the difference between the years for the same application and parameter (p<0.05). Data are expressed as ± standard error.

Table 7. The effects of fertilizers on the values of leaf color (b), Chroma° and hue°

2019	**b***		***Chroma°***		***hue°***	
Control	29.11 ± 0.58	A	33.08 ± 0.50	A	118.46 ± 0.54	B
Chemical	27.66 ± 2.45	A	31.93 ± 2.33	A	120.16 ± 1.56	
Organomineral	27.13 ± 1.90	A	31.40 ± 1.84	A	120.46 ± 1.08	
Cattle manure	27.74 ± 0.55	A	31.88 ± 0.55	A	119.65 ± 0.38	
Vermicompost	26.14 ± 0.78	A	30.26 ± 0.80	A	120.09 ± 0.56	B
Mean	27.55 ± 0.63		31.71 ± 0.60		119.76 ± 0.40	
$p_{fertilizer}$	0.710		0.723		0.601	
2020						
Control	20.34 ± 1.24b	B	23.97 ± 1.36b	B	121.44 ± 0.97	A
Chemical	20.20 ± 1.01b	B	23.64 ± 1.01b	B	121.50 ± 0.82	
Organomineral	20.42 ± 0.40b	B	24.08 ± 0.51b	B	122.28 ± 0.15	
Cattle manure	24.21 ± 1.17a	B	28.14 ± 1.10a	B	120.97 ± 0.95	
Vermicompost	21.45 ± 0.59ab	B	25.23 ± 0.61ab	B	121.81 ± 0.31	A
Mean	21.33 ± 0.51		25.01 ± 0.54		121.60 ± 0.31	
$p_{fertilizer}$	0.042		0.029		0.772	
			Years average			
Control	24.73 ± 1.77		28.52 ± 1.85		119.95 ± 0.76	
Chemical	23.93 ± 1.87		27.78 ± 1.96		120.83 ± 0.85	
Organomineral	23.77 ± 1.55		27.74 ± 1.64		121.37 ± 0.61	
Cattle manure	25.97 ± 0.89		30.01 ± 0.91		120.31 ± 0.54	
Vermicompost	23.79 ± 0.99		27.74 ± 1.06		120.95 ± 0.44	
$p_{fertilizer}$	0.800		0.804		0.588	

Small letters show the difference among the applications for the same year and years average. Capital letters show the difference between the years for the same application and parameter (p<0.05). Data are expressed as ± standard error.

When the data is analyzed; in terms of leaf color b* and Chroma° parameters, the difference between fertilizers and between years in all applications for 2020 was found to be significant (Table 7). In the data obtained from the leaf hue° parameter; the difference between years was found to be significant for the control group and vermicompost applications. While the color b* value indicates the color changes from yellow (positive) to blue (negative), the C* value determines the saturation of the color increases as the value increases (Kibar et al., 2020). The hue (h) value, one of the color criteria in the study, is used to express the whole ratio of basic colors (Çavuşoğlu and Gökçenay, 2018). In a study in which the effects of salt and putrescine applications on germination and seedling growth in beans were determined, it was found that the b* value of leaf color varied between 16.62 and 23.22, Chroma (C*) value between 18.71 and 25.62, and hue° color values between 116.83 and 118.29 (Kibar et al., 2020). Leaf color b* values in all genotypes of boron applications at different times were found to be lower than the values in control applications, and an increase was observed in the leaf color C* values of the genotypes in parallel with increasing boron concentrations. It has been reported that the color b* value varies between 12.39 and 21.78, the C* value varies between 15.62 and 22.36, and the hue value varies between 96.28 and 128.13 (Akoğlu, 2013).

Conclusion and Recommendations

When the average of years is examined in the results obtained in the current study; it was determined that plant height, stem diameter, the number of nodes, flower bud length, flower bud width, stem length, the number of flower buds per cluster, bract length, middle leaflet length, the number of leaves, first pod height, pod length, pod width, the number of pods per bunch, pod weight, pod thickness, and chlorophyll (SPAD) values increased compared to the control group for all fertilizer applications. Organomineral and vermicompost fertilizers were equivalent to chemical fertilizers in plant height, stem diameter was slightly higher than other studies due to the variety difference. The number of internodes did not show any change in cattle manure compared to the control group, and chemical and vermicompost fertilizers for internode length decreased compared to the control group. In the number of nodes with the first flower, all fertilizer applications except chemical fertilizer increased compared to the control group. In the number of seeds in the pod, all fertilizer applications increased compared to the control group, except for cattle fertilizer application. While all fertilizer applications except cattle manure for leaf color L* were compared to the control group, it was determined that all fertilizer applications were lower than the control group. All fertilizer applications were greener than the control group because the negative a* value indicated greener color. When the leaf color b*, Chroma° and hue° results obtained from the study are examined; it was determined that different results were obtained according to fertilizer applications and years. Moreover, the data obtained from these parameters were in agreement with previous studies. it has been determined that this agreement is within the value range obtained from the results of previous studies and that bean genotypes may differ from each other in terms of variety characteristics. So, organic and organic mixed fertilizers could give equivalent or better results than chemical fertilizers. In the bean plant with different fertilizer applications, the best results were found in vermicompost fertilizer and organomineral fertilizer, which is chemical mineral fertilizers with organic matter, and it was determined that they had equivalent or better results than chemical fertilizers. In addition, it is important to test organomineral and vermicompost fertilizers with different ratios and combinations in future studies, where the best results are obtained from fertilizer applications. In addition, it is thought that these fertilizer applications will be beneficial in terms of determining the best fertilizer combination that can be offered as an alternative to chemical fertilizer in bean cultivation with the results to be obtained with different combinations of micronutrient additives.

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