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Morphologic And Agronomic Characteristics of Some Bean (*Phaseolus vulgaris* L.) Breeding Lines

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HIGHLIGHTS

- It is important to protect the gene pool and benefit from genetic diversity.
- Yield and quality in green bean production are still not at the desired level.
- Determining the morphological and agronomic characteristics is essential for bean breeding.

Abstract

In this study, some morphological and agronomic characteristics of 96 bean breeding lines (51 bush and 45 climbers) were investigated. Plant characteristics (anthocyanin coloration of hypocotyls, the intensity of anthocyanin coloration of hypocotyl, growth type, plant architecture, plant type, plant height, plant speed of climber), properties of leaves (intensity of green color, rigidity, terminal leaflet size, terminal leaflet shape, terminal leaflet length of the tip), flower properties (inflorescences position, size of bracts, color of flag leaf, color of wing), pod characteristics (pod length (except beak), width, thickness, shape of cross-section, ground color, intensity of ground color, presence of secondary color, secondary color, density of flecks of secondary color, stringiness of ventral suture, degree of warp, shape of warp, shape of distal part (except beak), length of beak, curling of beak, texture of surface) were determined and measured by using UPOV parameters and subjected to cluster analysis in morphological identification. In the dendrogram, bush bean lines were divided into two main groups and eight subgroups, and climber bean lines were also divided into two main groups and ten subgroups.

Keywords: : Bean (Phaseolus vulgaris L.), Morphologic and Agronomic Characteristics, Cluster Analysis.

1. Introduction

Bean (*Phaseolus vulgaris* L.) is a member of the Leguminosae family and is produced in North and Central America, South America, East and South Africa, West and South East Europe and East Asia (Adams et al., 1985). World fresh (green) bean production is nearly 24.5 million tons on an area of 1.6 million ha. While China is the first in fresh bean production with 19,5 million tons, Türkiye meets 2.6% of the world's production with 640.000 tons and ranks fourth after China, Indonesia, and India. While the world average yield is 1.53 tons per decare, it has been 1.38 tons in Türkiye (FAO 2021). In Türkiye, The Black Sea Region is the most producer

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with 180.000 tons (especially the Central Black Sea Region), followed by the Mediterranean and Aegean Regions (165.485 tons and 100.640 tons, respectively) (TUIK 2021).

However, the agronomic and morphological characteristics of the bean are different and the consumption area is widespread and diverse in parallel revealing the necessity of bringing a different approach to the bean breeding process. Thus, it is of great importance to protect the genetic diversity of the bean cultivated and to benefit from the genetic diversity.

There has been a very important development trend in bean agriculture in recent years in land surveys and interviews with companies engaged in the trade of seeds on the subject. In addition to the dry grains of the bean, immature fruits and grains are used as vegetables. Fresh fruits and grains contain around 90% water. Although the crude protein ratio in dry grains varies according to the variety and cultivation technique, it is 22% on average (Şehirali 1988).

Bean protein is rich in Lysine, Leucine, and Isoleucine amino acids, and poor in Methionine, Tryptophan and Cystine. Grain contains more vitamin A (carotene) and vitamin C in the green maturity period and less in the dry maturity period (Anlarsal 2014). Beans, which are consumed both fresh and dry, have a superior place among similar foods in terms of the high protein content of their grains, the fact that their proteins are close to meat protein in terms of amino acid composition and that they are rich in carbohydrates, calcium, iron and especially phosphorus. On the other hand, the content of sulfur-containing amino acids in beans is higher than in other legumes, which ensures a high biological value of bean protein (Çavuşoğlu and Akçin 2007). In this context, it is understood how important a vegetable is for our country's agriculture. However, the bean is known as a self-pollinating plant and producers often choose to produce their seeds. This turns out to be the main source of many problems. In recent years, there have been important developments in the use of certified seeds in beans in Türkiye.

Despite this, yield and quality in green bean production is still not at the desired level. Among the possible reasons for this, problems arising from the cultivation technique, problems arising from not using certified seeds and pathogen problems are the first ones that come to mind. In this context, it is a fact that there is a need for green bean varieties that are highly competitive, productive, less affected by late harvest, and compatible with consumer demands, both in the domestic market and in the foreign market. Thus, gene resources consisting of commercial, domestic and foreign bean lines constitute the material of this study. Our research, which is the first step of breeding bean varieties suitable for fresh consumption, is considered original and important in this aspect.

In this study, 96 different lines were grown under greenhouse conditions. In each line grown, morphological and agronomic characteristics were tried to be determined in line with measurements and observations created by using UPOV parameters. Thus, it is aimed to create the initial material of the bean breeding project suitable for fresh consumption, which is planned to be carried out later.

2. Materials and Methods

A total of 51 bush and 45 climber bean lines, including 30 bush and 39 climber bean lines obtained from Prof. Dr. Önder Türkmen (Selcuk University, Horticulture Department of Agriculture Faculty, Türkiye), and 21 bush and 6 climber bean lines supplied from Biotek Seed Company, were used as plant material.

2.2. Methods

2.2.1. Soil preparations, planting and cultural practices

Before sowing the seeds, soil samples were taken from the 0-30 cm deep part of the greenhouse to be tested, and soil analysis was carried out. As a result of the analysis, the soil structure was loamy, pH neutral, salt-free, very calcareous, high in phosphorus, lower in potassium and low in organic matter (Table 1).

Table 1. Soil analysis results of the experimental greenhouse

Specification	Amount	Class
Soil structure	%49.5	Loamy
pH	7.36	Neutral
Calcareous ($CaCO_3$)	27.57	Very calcareous
Salt (%)	0.0675	Salt-free
Phosphorus (P_2O_5)	10.82	High
Potassium (K_2O)	31.08	Lower
Organic matter (%)	1.29	Low

The greenhouse soil was maintained with a plow and a disc harrow, the first fertilization was realized according to the soil analysis and the drip irrigation lines were adjusted following the spacing between and within the rows, and the seeds were planted with 50x20 cm spacings. 40 plants were grown from each line with 4 replications. Irrigation, fertilization (fertigation), weed control, disease and pest management were carried out regularly.

2.2.2. Determination of morphological and agronomic characteristics

The characterization of the bean breeding lines was realized according to the International Union for the Protection of New Varieties of Plants (UPOV 1998) guidelines. The examined characteristics, the classes of these characteristics and the class scores used in the rating scale are presented in Table 2.

The presence of anthocyanin in the hypocotyl and the anthocyanin density were determined when the plants had 5-6 leaves. Pod lengths (cm) and pod diameters (cm) of bean lines were measured at the fresh consumption stage (Figure 1). To obtain mature seeds, the pods whose shells begin to dry were carefully harvested and dried in a shaded area (Figure 2).

Figure 1. Measuring the length and stem diameter of pods

Figure 2. Drying of harvested pods (left side) and seeds (right side)

Table 2. Characteristics (CH), classes of these characteristics and class scores (CS) were examined in the morphological characterization of bean lines.

	CH	Classes	CS		CH	Classes	CS
PLANT	Anthocyanin in the hypocotyl	Absent	1	POD	Length (except beak)	Short	3
		Current	9			Medium	5
						Long	7
						Very long	9
	Intensity of anthocyanin in the hypocotyl	Little	3		Width	Narrow	3
		Medium	5			Medium	5
		Strong	7			Broad	7
	Growth type	Bush	1		Thickness	Thin	3
		Climber	2			Medium	5
						Thick	7
						Very thick	9
	In climber types	Pyramid	1		Shape of cross-section	Elliptical	1
		Rectangle	2			Egg	2
						Heart	3
						Round	4
	In bush types	Without spreading	1		Ground color	Yellow	1
		Spreading	2			Green	2
	Height in bush	Short	3		Intensity of ground color	Low	3
		Medium	5			Medium	5
		Tall	7			Dark	7
	Climber speed	Slow	3		Pres. of secondary color	Absent	1
		Medium	5			Current	9
		Fast	7				
LEAF	Intensity of green	Light green	3		Intensity of secondary color	Rarely	3
		Green	5			Medium	5
		Dark green	7			Intense	7
		The darkest gr.	9				
	Rigidity	Absent/Very little	1		Secondary color	Absent	1
		Low	2			Pink	2
		Medium	3			Red	3
						Violet	4
	Terminal leaflet size	Small	3		Stringiness of ventral suture	Absent	1
		Medium	5			Current	9
		Large	7				
	Terminal leaflet shape	Triangle	1		Degree of Warp	Absent/Very little	1
		Triangle-circle	2			Little	3
		Circle- rhombus	3			Medium	5
		Rhombus	4			Strong/Very Strong	7

Table 2 (Continued). Characteristics (CH), classes of these characteristics and class scores (CS) were examined in the morphological characterization of bean lines

	Terminal leaflet length of the tip	Short Medium Long	1 2 3	Shape of warp	Inwards	1 2
FLOWER	Flower location in bush at full blooming	Partly in leaf In leaf On leaf	1 2 3	Shape of distal part (except beak)	Pointed Pointed to blunt Blunt	1 2 3
	Size of the bracts	Small Medium Large	3 5 7	Length of Beak	Short Medium Long	3 5 7
	Color of flag leaf	White Pinkish white Violet	1 2 4	Curling of beak	Absent/ Very little Low Medium Strong/Very strong	1 3 5 7
	Color of wing	White Pinkish white Pink Violet	1 2 3 4	Texture of surface	Smooth/ Slig. rou. Medium rough	1 2

2.2.3. Data evaluation

Following the characterization of the bean breeding lines, the data obtained to determine the level of variation in the lines were subjected to statistical analysis in the SPSS package program. A dendrogram was created to show the similarities and differences between the lines with each other. The dendrogram created in the study is the 'Similarity between groups' dendrogram. This dendrogram was obtained by performing Cluster analysis according to Ward's method (Rohlf, 1993). The pod lengths and pod diameters of the bean lines were analyzed in the JMP 10 statistical program and grouped according to the LSD 5% significance level.

Due to the differences in some parameters of the UPOV criteria, bean lines were evaluated separately as bush and climber.

3. Results

3.1. Morphological characteristics of bush and climber bean lines

3.1.1. Plant characteristics

Anthocyanin formation was not visualized in all bush beans. Anthocyanin was found in 4 (9%) lines of the climber bean, and the anthocyanin coloration was low in 2 lines, moderate in 1 line, and strong in 1 line. In bush beans, 23 lines (45%) grew in the spreading type, while 28 lines (55%) showed growth in the non-spreading type. 3 lines (6%) were short plant height, 31 lines (61%) were medium and 17 lines (33%) were tall.

In climber beans, 32 lines (71%) had pyramid growth and 13 lines (29%) had rectangular growth shapes. The rate of climbing was determined as slow in 2 lines (4.5%), medium in 1 line (2%), and fast in 42 lines (93.5%).

There are differences in plant height between genotypes and the main reasons for these differences are; climatic and soil conditions and elevation, cultural practices and genetic predisposition (Baran, 2018). It has been reported that the main reason for the variation in plant height is the high heritability (85-92%) and also the genotype (Çiftçi and Şehirali 1984; Sözen et al. 2012; Akbalık 2019; Bıyıklı et al. 2021)

Işık (2012) reported that 73% of the lines were bush and 27% were semi-climber form, and similar results were argued by Akbulut et al. (2014). In another study, 15% of the lines were bush, 19% were semi-climber, and the rest (66%) were in the climber form (Sözen et al. 2012). In a study conducted in the Eastern Black Sea Region, 14% of the lines were found the bush, 49% semi-climber and 37% climber form (Sözen et al. 2014a).

3.1.2. Leaf characteristics

In the bush lines, the green color intensity in the leaves was predominantly green (61%). Leaf rigidity was absent or very little in the majority of the lines (69%), low in 14 lines (27%) and moderate in 2 lines (4%). The terminal leaflet size was small in 7 lines (14%), medium in 32 lines (63%), and large in 12 lines (23%).

The climber bean lines also generally had green leaf color (58%), 2 lines (4.5%) were light green, 16 lines (35.5%) were dark green and 1 line (2.2%) was very dark green. Leaf rigidity was absent or very little in 39 lines (87%) and less in 6 lines (13%). The terminal leaflet size was determined as small in 21 lines (47%), medium in 17 lines (38%) and large in 7 lines (15%). Bean lines showed 3 variations (light, medium, dark) in terms of the leaf green hue color of lines, 17.6% of subsamples had light, 71.7% medium and 10.7% dark leaf green color (Sözen et al. 2014b).

Işık (2012) reported that the lines had 4 different leaf colors green, light green, very light green and dark green, and the majority (51.5%) showed green leaf characteristics. In addition, it was determined that 12 lines showed less and 21 lines showed moderate rigidity. 42.4% of the lines had a middle-pointed leaflet shape. Similar results were found in previous reports, and most of the lines had green leaf color (Işık 2012; Sözen et al. 2012; Sözen et al. 2014a; Sözen et al. 2014b; Akbulut et al. 2014). The fact that some of our results do not correspond with previous studies is due to the difference in the lines we used.

3.1.3. Flower characteristics

In bush beans, flowers (at full bloom time) were partially in the leaf in 42 lines (82%), in the leaf in 6 lines (12%) and on the leaf in 3 lines (6%). At the size of the bracts, 32 lines (63%) were small, 5 (10%) medium and 14 (27%) large lines. It was determined that 37 lines (72.5%) were white in flag leaf color, 13 lines (25.5%) were pinkish white and 1 line (2%) was violet.

It was determined that 9 lines (20%) were small, 20 lines (44.5%) were medium and 16 lines (35.5%) were large in terms of the size of the petal in climber lines. In the evaluation made in terms of flag and wing leaf color, 27 lines (60%) were white, 9 lines (20%) were pinkish white, 2 lines (4.4%) were pink and 7 lines (15.6%) were violet.

Işık (2012) reported that 21% of the lines had white flowers and 79% had lilac flowers. The flower color in bush lines was white in 3 lines and lilac in 21 lines, while 4 lines were white and 5 lines were mauve in lanceolate forms. Akbulut et al. (2014) found a pink and white flower in bean lines. In our study, the white flower was observed at a rate of 66%. This result differs from the data obtained by Işık (2012) (72% lilac flower) due to the difference in lines used.

3.1.4. Pod characteristics

While 8 lines (16%) had short pod length (excluding beak), 21 lines (41%) had medium, 17 (33%) long pods, and 5 lines (10%) had very long pods in the bush lines. 17 lines (33%) were determined as narrow podded, 23 lines (45%) as medium and 11 lines (22%) as broad podded.

The pod thickness was found to be thin in 11 lines (22%), medium in 27 lines (53%), thick in 9 lines (17%) and very thick in 4 lines (8%). In the shape of the cross-section of the broad bean (towards the seed), 23 lines (45%) were elliptical, 9 lines (17.5%) were egg-shaped, 12 (23.5%) were heart-shaped, 7 lines (14%) were round.

It was determined that 1 line (2%) was yellow and 50 lines (98%) were green in bush beans. 7 lines (13%) had low intensity, 34 (67%) medium and 10 (20%) dark pods. While there was no second color in the pod in 47 lines (92%), it was found in 4 lines (8%). The second color of the broad bean was violet in 4 lines (8%).

There was no stringiness in 47 lines (92%) and it was present in 4 lines of bush beans (8%). 35 lines (68%) had no or very little warp in the pod, 10 lines (20%) were low, 4 lines (8%) were medium, 1 line (2%) was strong and 1 line (2%) was very strong. The pods of 16 lines (31%) were found to warp inwards, while no warp was observed in 35 lines (68.6%). In the shape of the distal part of the pod (except the beak), 26 lines (51%) were pointed, 16 lines (31%) were pointed to blunt, and 9 lines (18%) were blunt. The pod beak length was short in 10 lines (20%), medium in 23 lines (45%), and long in 18 lines (35%). It was determined that 25 lines (49%) had no or very little curling in the beak, 11 lines (21%) were low, 5 lines (10%) were medium, 7 lines (14%) were strong and 3 lines (6%) were very strong. It was determined that the pod surface structure was smooth or slightly rough in 46 lines (90%) and medium rough in 5 lines (10%).

In climber beans, pod length (excluding beak) was found to be 7 lines (16%) very short, 10 lines (22%) short, 15 lines (33%) medium, 7 lines (16%) long and 6 lines (13%) very long. determined. While 13 lines (29%) had narrow pods, 8 lines (18%) had medium and 24 lines (53%) had wide pods. It was determined that 9 lines (20%) were thin, 24 lines (53%) were medium, 6 lines (13%) were thick and 6 lines (13%) were very thick. The cross-section of the broad bean (towards the seed) was elliptical in 23 lines (51%), eggs in 8 lines (18%), heart in 13 lines (29%), and eight in 1 line (2%).

The pod's ground color was yellow for 3 lines (7%), green for 40 lines (89%), and violet for 2 lines (4%). The intensity of the pod background color was determined as low in 8 lines (18%), medium in 31 lines (69%), and dark in 6 lines (13%). While the second color did not observe in 23 lines (51%) in pods, it occurred in 22 lines (49%). The second color of the broad bean was determined as pink in 5 lines (22%), red in 1 line (5%) and violet in 16 lines (73%). The intensity of the second color spots in the pod was rare for 13 lines (29%), medium for 4 lines (9%), and intense for 5 lines (11%). While there was no stringiness in 27 lines (60%), it was determined in 18 lines (40%).

27 lines (60%) had little or no warp in the pod, low in 14 (31%) lines, medium in 3 lines (7%), and strong in 1 line (2%). While the pod warp was inward in 18 lines (40%), it was not observed in 27 lines (60%). The shape of the distal part (except the beak) was pointed in 27 lines (60%), pointed to blunt in 12 lines (27%), and blunt in 6 lines (13%). The beak length of the pod was determined as short in 10 lines (22%), medium in 22 lines (49%), and long in 13 lines (29%). It was determined that 31 lines (69%) had no or very little curling in the beak, 9 lines (20%) were low, 3 lines (7%) were medium, and 2 lines (4%) were strong. The pod texture was smooth or slightly rough in 29 lines (65%), and medium rough in 16 lines (35%).

3.1.5. Pod lengths (PL) and pod diameter (PD)

The PL of the lines varied according to the lines (Table 3). Lines O45 (24.12 cm) and O41 (22.87 cm) formed the longest pods, while O10 and O12 (12.75 cm), O36 (12.12 cm), O30 (11.65 cm) and O27 (10.12 cm) had the shortest pods. The average PL of 51 bush lines was found to be 16.38 cm. When the PD is examined, O18 and O19 (1.87 cm), O32 (1.82 cm) and O26 (1.75 cm) lines had the widest pods, O17 (0.97 cm), O16 (0.92 cm), O21 (0.90 cm), O8 (0.82 cm) and O5 (0.75 cm) produced the narrowest pods. Average PD was measured as 1.36 cm in bush lines.

Genotype differences were also found in the PL of the climber lines. S4 (26.32 cm) and S1 (25.02 cm) lines were the longest pods, while the shortest pods were harvested at S13 and S38 (8.9 cm), S12 (8.20 cm), S44 (7.82 cm) and S27 (5.80 cm). The average PL of bush lines was determined as 13.15 cm. The widest pods were in S6 (2.00 cm), S34 and S45 (1.97 cm) and S4 (1.92 cm), while S38 (1.02 cm), S14 (1.00 cm), S13 (0.97 cm), S8 (0.95 cm) and S12 (0.92 cm) formed the narrowest pods. The average PD was determined as 1.35 cm in climber lines (Table 3).

It has been reported that pod length is a genetic character and is affected by growing conditions and environmental conditions (Karasu 1988). In other studies, the pod length was between 7.42-30.59 cm (Pekşen 2005; Seymen et al. 2010; Demir 2011; Varankaya and Ceyhan 2012; Ekincialp and Şensoy 2013; Özbekmez 2015; Topal 2019; Nadeem et al. 2020; Şener and Kaya 2022). Yorgancılar (1995) determined the pod length as 7.6-13.82 cm and the thickness as 5.62-9.26 mm in dwarf bean genotypes. Sarı et al. (2016), in bean genotypes with different seed colors collected from the Black Sea Region, the pod length was between 8.53 cm and 70.28 cm. In the width of the link, the lowest value was 6.56 mm, while the widest link was 19.76 mm. Genotypes had pod thickness varying between 6.58 and 10.78 mm. Sözen et al. (2012) defined 106 genotypes to determine the biodiversity of bean populations collected from the Western Black Sea Region and stated that 90 genotypes did not show an awning feature.

Sözen et al. (2014a), as a result of the characterization study they performed on local bean populations in the Eastern Black Sea Region, found that 10 of 85 genotypes (11.7%) were narrow, 54 of them (63.5%) were medium, and the remaining 21 (24.8%) were broad pods in terms of pod width. In addition, it was determined that 8 genotypes had elliptical (9.1%) pod cross-sectional shape, 17 of them were cordate (19.3%), 40 of them were circular (47.4%) and 21 of them were 8-shaped (24.2%). While 32.9% (28 units) of the genotypes were stringiness, 67.1% (57 units) showed awny features. It has been determined that boneless genotypes can be selection material to develop varieties suitable for green beans.

Akbulut et al. (2014) observed that among the 12 genotypes, pigment formation occurred only in Black beans and the color of this pigment was "Purple". Similarly, the pigment spots in the pods were "Intense". The roughness of the pods in genotypes was generally observed as "flat". While stringiness was observed in half of the genotypes, the awning was not detected in Akbağlaklı, Gina, Karataneli, Roma, Sarıkız and Şeker. The length of the pod varied between 11 cm (White Pole) and 15 cm (Akbağlaklı, Gina and Roma), and the average length of the pod was 13.31 cm. Işık (2012) did not find mottling in any of the 33 genotypes. In addition, it was determined that all genotypes had a smooth leaf structure. Except for 3 genotypes, all genotypes showed stringiness.

The stringiness was not observed in most of the genotypes in our study, and this result was largely similar to previous studies and differed from some of them. It was determined that these differences were caused by the differences in the genotypes we used. In terms of pod width, in our study results, it was found that there was a difference between bush and climber genotypes, medium and wide.

Table 3. Pod lengths (PL; cm) and pod diameter (PD; cm) of bush and climber bean lines (L)

Bush			**Climber**		
L	**PL (cm)**	**PD (cm)**	**L**	**PL (cm)**	**PD (cm)**
O1	17.25 e-ı	1.42 ıj	S1	25.02 a	1.47 def
O2	17.17 e-ı	1.55 e-ı	S2	16.07 cde	1.15 k-q
O3	18.22 def	1.40 jk	S3	15.70 d-g	1.07 n-t
O4	15.50 l-p	1.42 ıj	S4	26.32 a	1.92 abc
O5	14.57 pqr	0.75 u	S5	15.95 c-f	1.47 def
O6	15.02 o-r	1.65 c-f	S6	21.37 b	2.00 a
O7	16.87 f-l	1.57 d-h	S7	9.55 rst	1.05 o-t
O8	17.67 e-h	0.82 tu	S8	10.77 o-r	0.95 st
O9	14.42 pqr	1.67 cde	S9	20.62 b	1.15 k-q
O10	12.75 st	1.62 c-g	S10	14.55 e-ı	1.50 de
O11	17.75 e-h	1.65 c-f	S11	11.47 n-q	1.17 j-p
O12	12.75 st	1.42 ıj	S12	8.20 t	0.92 t
O13	16.57 h-n	1.52 f-j	S13	8.90 st	0.97 rst
O14	17.55 e-h	1.00 p-s	S14	9.20 rst	1.00 q-t

Table 3 (Continued). Pod lengths (PL; cm) and pod diameter (PD; cm) of bush and climber bean lines (L)

O15	15.32 n-q	1.05 o-r	S15	10.45 p-s	1.05 q-t
O16	14.80 o-r	0.92 rst	S16	13.67 h-l	1.77 c
O17	15.00 o-r	0.97 qrs	S17	15.02 e-h	1.20 j-o
O18	18.32 de	1.87 a	S18	12.25 l-o	1.22 ı-n
O19	16.75 g-m	1.87 a	S19	12.22 l-o	1.15 k-q
O20	18.15 d-g	1.55 e-ı	S20	12.72 k-n	1.55 d
O21	14.85 o-r	0.90 st	S21	14.82 e-h	1.27 h-l
O22	14.00 qrs	1.10 n-q	S22	11.77 m-q	1.77 c
O23	17.07 e-j	1.70 bcd	S23	14.30 f-j	1.82 bc
O24	15.05 o-r	1.50 g-j	S24	10.17 p-s	1.77 c
O25	15.25 n-q	1.00 p-s	S25	15.17 e-h	1.47 def
O26	14.75 o-r	1.75 abc	S26	13.80 h-l	1.45 d-g
O27	10.12 u	1.10 n-q	S27	5.80 u	1.30 g-k
O28	15.62 k-p	1.52 f-j	S28	13.45 h-m	1.37 e-ı
O29	15.45 m-p	1.42 ıj	S29	10.42 p-s	1.12 l-r
O30	11.65 t	1.10 n-q	S30	17.12 cd	1.22 ı-n
O31	15.15 opq	1.27 kl	S31	11.87 m-p	1.37 e-ı
O32	17.87 e-h	1.82 ab	S32	14.05 g-k	1.42 d-h
O33	15.75 j-p	1.67 cde	S33	11.45 n-q	1.25 ı-m
O34	15.37 m-q	1.55 e-ı	S34	11.75 m-q	1.97 ab
O35	16.10 ı-o	1.52 f-j	S35	10.07 qrs	1.55 d
O36	12.12 t	1.20 lmn	S36	10.25 p-s	1.20 j-o
O37	17.25 e-ı	1.40 jk	S37	9.12 rst	1.12 l-r
O38	17.00 e-k	1.25 lm	S38	8.87 st	1.02 p-t
O39	12.97 st	1.12 m-p	S39	13.05 ı-n	1.32 f-j
O40	18.40 de	1.05 o-r	S40	9.12 rst	1.12 l-r
O41	22.87 a	1.57 d-h	S41	14.60 e-ı	1.42 d-h
O42	20.97 b	1.12 m-p	S42	12.40 k-o	1.32 f-j
O43	19.50 cd	1.15 l-o	S43	13.07 ı-n	1.27 h-l
O44	21.15 b	1.15 l-o	S44	7.82 t	1.10 m-s
O45	24.12 a	1.17 l-o	S45	17.50 c	1.97 ab
O46	19.90 bc	1.15 l-o	**Average**	13.15	1.35
O47	17.62 e-h	1.45 hıj		LSD : 1.745	LSD: 0.160
O48	13.65 rs	1.25 lm			
O49	16.65 h-n	1.72 bc			
O50	14.57 pqr	1.62 c-g			
O51	20.42 bc	1.15 l-o			
Average	16.38	1.36			
	LSD: 1.414	LSD: 0.141			

When the literature studies are examined, it is seen that the medium width is highly common. There is a difference between our study results and literature studies in terms of pod cross-section. However, on the presence of secondary color in the pod, our study results were compatible with the reported literature. In our study, a high rate of roughness was not observed in genotypes, this rate was found to be 50% by Akbulut et al. (2014). According to our study results, the warp shape and degree of warp in the pod are closely following the literature. Our findings in the length and width parameters of the pod agree with the Akbulut et al. (2014) findings, but not following the Sarı et al. (2016). It is thought that the main reasons why some of the results we obtained in our study did not agree with the literature were the difference in the genotypes and that our study was conducted under greenhouse conditions.

4. Discussion

4.1. Determination of the Variation in Bean Breeding Lines.

4.1.1. Dendrogram Analysis of Bush Bean Lines

All the data obtained were subjected to cluster analysis to determine the relationship between the examined traits and lines belonging to 51 genotypes. It is seen in the dendrogram (Figure 3) that the criteria we examined also vary in terms of morphological character.

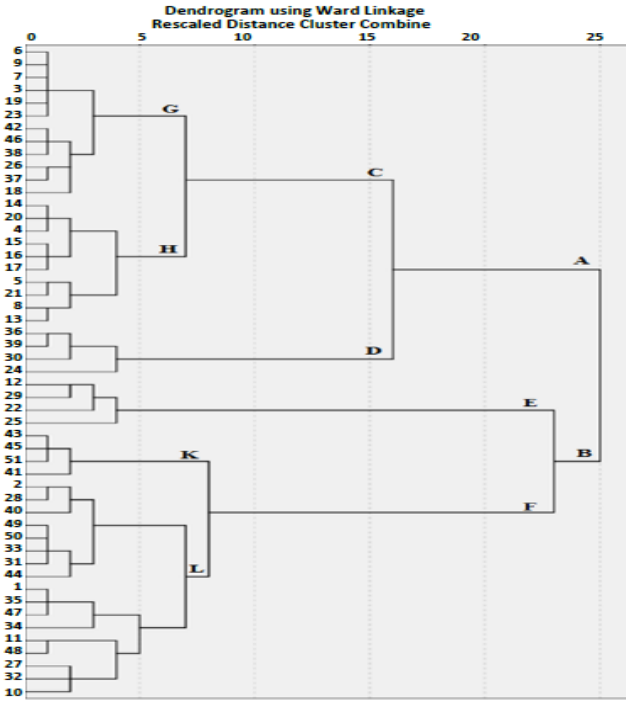

Figure 3. Dendrogram formed by morphological measurements and observations in bush lines

As presented in the dendrogram the lines were divided into two main groups (A and B). Group A is divided into two main groups, one of large (C) and the other of small (D). Of these main groups, the C is again divided into two sub-groups, one of big (G) and the other of small (H), and the G is also divided into two branches. Lines O6 and O9, O15 and O16, and O36 and O39 were found to be closely related to each other in G, H, and D, respectively.

The second large main group of the dendrogram (B) is divided into two main groups, one of large (F) and the other of small (E). Among these main groups, group F is again divided into two subgroups, one of large (L) and the other of small (K). L is also divided into two branches. In the L, lines O49 and O50, O43 and O45, O12 and O29 were found to be closely related to each other in L, K, and E, respectively. In the bush lines, the lines O6 and O9 were the closest to each other and the lines O1 and O3 were the farthest from each other. By subjecting the obtained data to principal component analysis, it was possible to explain the connection between the bush lines (Table 4).

Table 4. Proximity-distance relationships of bush genotypes according to Ward Linkage

Agglomeration Schedule

	Cluster Combined			Stage Cluster First Appears		
Stage	**Cluster 1**	**Cluster 2**	**Coefficients**	**Cluster 1**	**Cluster 2**	**Next Stage**
1	16	17	5,000	0	0	8
2	50	51	10,000	0	0	11
3	43	47	13,000	0	0	13
4	2	36	13,000	0	0	20
5	8	10	13,000	0	0	6
6	4	8	15,500	0	5	10
7	44	46	16,000	0	0	16
8	16	21	16,500	1	0	21
9	20	24	17,000	0	0	17
10	4	7	17,667	6	0	17
11	34	50	18,000	0	2	23
12	12	49	18,000	0	0	38
13	39	43	18,500	0	3	25
14	6	22	19,000	0	0	27
15	5	15	19,000	0	0	24
16	44	52	21,000	7	0	30
17	4	20	23,000	10	9	26
18	37	40	24,000	0	0	36
19	3	29	24,000	0	0	31
20	2	48	26,500	4	0	33
21	16	18	27,000	8	0	24
22	9	14	27,000	0	0	27
23	32	34	29,000	0	11	29
24	5	16	30,250	15	21	34
25	27	39	33,333	0	13	26
26	4	27	33,833	17	25	28
27	6	9	34,000	14	22	34
28	4	19	40,600	26	0	35
29	32	41	40,750	23	0	31
30	42	44	41,000	0	16	39
31	3	32	41,600	19	29	35
32	13	30	46,000	0	0	42
33	2	38	47,000	20	0	38
34	5	6	48,250	24	27	40
35	3	4	50,675	31	28	40
36	31	37	52,000	0	18	46
37	28	33	52,000	0	0	41
38	2	12	53,500	33	12	43
39	42	45	57,250	30	0	44
40	3	5	60,856	35	34	43
41	11	28	66,000	0	37	44
42	13	23	69,000	32	0	45
43	2	3	69,369	38	40	48
44	11	42	80,267	41	39	47
45	13	26	91,333	42	0	50
46	25	31	92,333	0	36	49
47	11	35	104,000	44	0	48
48	2	11	107,180	43	47	49
49	2	25	141,041	48	46	50
50	2	13	164,170	49	45	0

4.1.2. Dendrogram Analysis of Climber Bean Lines

All the data obtained were subjected to cluster analysis to determine the relationship between the examined traits and lines belonging to 45 genotypes. It is seen in the dendrogram (Figure 4) that the criteria we examined also vary in terms of morphological characters.

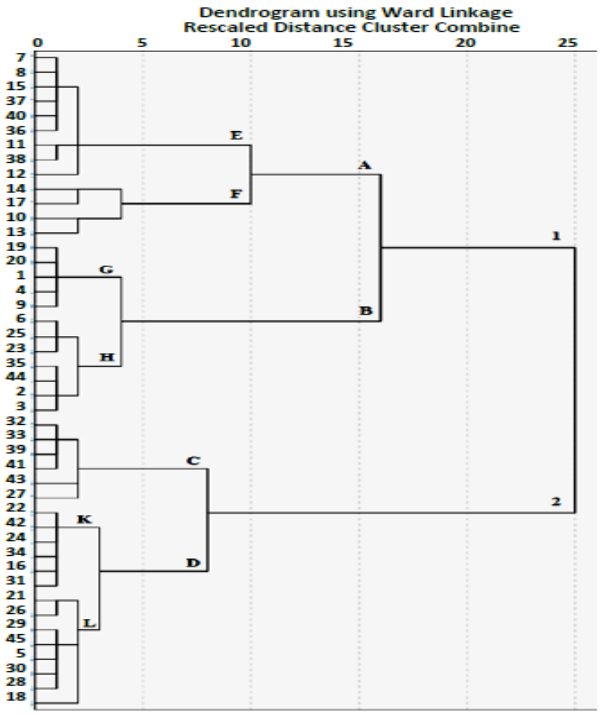

Figure 4. Dendrogram formed by morphological measurements and observations in climber lines

The lines were divided into two main groups, 1 and 2. Group 1 is divided into two main groups, one large (A) and the other small (B). Among these main groups, A is again divided into two sub-groups, one big (E) and the other small (F). Lines S7 and S8 in group E and lines S14 and S17 in group F were found to be closely related. The other main group, group B, is divided into two branches, one large (H) and the other small (G). Lines S19 and S20 in the G group, and lines S6 and S25 in the H group were found to be closely related.

The second large main group of the dendrogram, the 2 groups, is divided into two main groups, one large (D) and the other small (C). Among these main groups, the D group is again divided into two sub-groups, one large (L) and the other small (K). Lines S29 and S45 in group L, lines S24 and S34 in group K and lines S32 and S33 in group C were found to be closely similar. It was determined that there was variation between the lines, and according to the dendrogram analysis performed on the climber lines, it was determined that S7 and S8 were the closest lines to each other, and S1 and S5 were the farthest lines from each other. By subjecting the obtained data to principal component analysis, it was possible to explain the connection between the climber lines (Table 5).

Table 5. Proximity-distance relationships of climber genotypes according to Ward Linkage

Agglomeration Schedule

	Cluster Combined			Stage Cluster First Appears		
Stage	**Cluster 1**	**Cluster 2**	**Coefficients**	**Cluster 1**	**Cluster 2**	**Next Stage**
1	7	8	4,500	0	0	15
2	29	45	15,000	0	0	25
3	24	34	25,500	0	0	19
4	19	20	36,500	0	0	12
5	37	40	49,500	0	0	24
6	11	38	63,000	0	0	33
7	22	42	77,500	0	0	23
8	16	31	92,000	0	0	19
9	6	25	108,000	0	0	20
10	5	30	125,000	6	0	14
11	32	33	142,500	0	0	26
12	1	19	160,167	0	4	21
13	4	9	178,167	0	0	21
14	5	28	195,500	10	0	25
15	7	15	216,667	1	0	28
16	35	44	237,667	0	0	18
17	39	41	259,167	0	0	26
18	2	35	283,500	0	16	27
19	16	24	308,500	8	3	23
20	6	23	334,500	9	0	37
21	1	4	351,833	12	13	39
22	21	26	389,333	0	0	32
23	16	22	417,667	19	7	38
24	36	37	447,333	0	5	28
25	5	29	478,300	14	2	30
26	32	39	513,300	11	17	31
27	2	3	548,467	18	0	37
28	7	36	584,133	15	24	33
29	14	17	627,633	0	0	40
30	5	18	677,333	25	0	32
31	32	43	727,333	26	0	34
32	5	21	782,583	30	22	38
33	7	11	840,458	28	6	36
34	27	32	899,458	0	31	41
35	10	13	960,458	0	0	40
36	7	12	1023,861	33	0	42
37	2	6	1091,933	27	20	39
38	5	16	1184,492	32	23	41
39	1	2	1304,254	21	37	43
40	10	14	1439,004	35	29	42
41	5	27	1733,811	38	34	44
42	7	10	2096,168	36	40	43
43	1	7	2666,370	39	42	44
44	1	5	3596,044	43	41	0

5. Conclusion

In this study, morphological characterization was performed according to UPOV criteria in 51 bush and 45 climber bean lines. 33 morphological features were used for this characterization. In light of these, the level of variation and relations (proximity-distance) were tried to be determined. The results of our study revealed that the existing gene pool consists of lines with different characteristics that have the potential to be used for

different purposes in breeding studies. The fact that there are significant differences between some of the lines used in the study shows that different lines and eventually different cultivar candidates may emerge in future breeding studies and that the presented study may yield successful results. This situation will ensure that new bean varieties with agronomic superior characteristics, suitable for producer and consumer demands, will be brought to the market, and thus contribute to the country's economy, especially in our country where there are very few qualified bean varieties. It is thought that as well as the current breeding work carried out with the material we used in our study, can also support the breeding studies to be carried out in the future and make important contributions to the protection of bean gene resources.

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Conflicts of Interest The authors declare no conflict of interest.

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