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Research Article

Performance of Local Bean (*Phaseolus vulgaris* L.) Genotypes for Agronomic and Technological Characteristics

Aykut ŞENER*[1], Muharrem KAYA[2]

[1,2]Isparta University of Applied Sciences, Faculty of Agriculture, Department of Field Crops, 32200, Isparta, Türkiye

[1]https://orcid.org/0000-0003-1868-9451, [2]https://orcid.org/0000-0001-6973-9178

*Corresponding author e-mail: aykutsener@isparta.edu.tr

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Abstract: The experiments were carried out in the field condition in 2019 and 2020, using 68 local bean genotypes and 5 cultivars (Akın, Akman 98, Göynük 98, Önceler 98, and Yunus 90) according to the Augmented design. Results showed that there were significant variations among dry bean cultivars and genotypes in terms of all the characteristics examined. In 2019, the vegetation period was 99.7-180.3 days, the first pod height 6.81-15.81 cm, pods per plant 9.90-60.92, seed per plant 20.2-268.9, the seed yield 1227-5970 kg ha^{-1}, the hundred-seed weight 18.99-112.8 g, water-uptake capacity 0.137 - 1.443 g and seed protein content varied between 13.95-23.15%. In 2020, the vegetation period was 99.4-159.2 days, the first pod height 4.42-15.76 cm, pods per plant 11.13-89.40, seed per plant 23.8-277.1, the seed yield 581.4-6801 kg ha^{-1}, the hundred-seed weight 23.5-135.5 g, water-uptake capacity 0.236-1.483g and the seed protein content varied between 17.85-24.79%. It was found that there were promising local genotypes superior to the cultivars in the seed yield and yield characteristics.

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Footnote: This study is derived from the doctoral thesis of first author and titled "characterization in terms of some physiological, morphological, agronomical and technological properties of local bean (*Phaseolus vulgaris* L.) populations collected from different provinces".

1. Introduction

Human life depends on plants, and the foodstuffs used in nutrition are provided either directly from plants or from animals that feed on plants. In addition to nutrition, plants are also used to meet people's daily needs such as shelter, medical-nutraceutical, and wear. Although many plant products can be produced artificially (such as synthetic fiber and rubber), it has not been synthetically possible to produce strategic crops accounting for the basic food of 75% of the world's population, such as wheat, corn, beets, potatoes, paddy, beans, etc. Nowadays, malnutrition problems are one of the most important agendas in the world. As a matter of fact, according to 2017 data, 821 million people in the world were malnourished and faced starvation (FAO, 2018). Malnutrition and death from hunger continue in Asia, sub-Saharan Africa, and Oceania. In most countries, billions of people do not have access to protein-based foods necessary for adequate and balanced nutrition (Ünal, 2017).

Dry beans are classified as legumes that have the most cultivation area in the world. In 2020, the total cultivation area of dry bean was 33 million ha, the total production amounted to 29 million tons, and the average yield was 874.1 kg ha^{-1}. The highest dry bean producing countries in the world are Myanmar (5.8 million tons), India (5.3 million tons), and Brazil (2.9 million tons). Considering the food legumes in Türkiye, the cultivation and production of dried beans ranked third after chickpeas and lentils. In world bean production, Türkiye is ranked as the 21st country with approximately 280 thousand tons, obtained from 103 thousand ha cultivated area. The dry bean yield of Türkiye is above the world average, and its seed yield is 2715 kg ha^{-1} (FAO, 2020). In order to increase the production of beans both in the world and in Türkiye, along with the improvements in the growing techniques, new varieties with high yield and quality characteristics need to be developed.

While soil, water, and air are considered the main natural resources in crop production, "genetic resources" have been added to them as the fourth main natural resource. Plant genetic resources are extremely important for wide genotypic variation in plant breeding research. In this respect, one of the uses of local plant populations is the expansion of gene pools, which have been narrowed in modern cultivars. Nowadays, as modern cultivars that have high yields but narrow genetic bases lack genes for resistance (disease, pest, cold and arid), breeders are constantly looking for new sources of germplasm. In this respect, plant genetic resources are used directly or as bridge species to transfer quantitative characters in long-term programs and qualitative characters (disease resistance, etc.) in short or medium-term programs (Şehirali and Özgen, 1987). Furthermore, global problems manifested in the form of global warming and climate change have once again demonstrated the importance and value of genetic resources.

In recent years, numerous researches have been carried out in Türkiye to search for and discover new genetic resources. The ability to search and find a new genetic resource is unfortunately inadequate when it comes to its contribution to the economy. However, the most important contribution of this material can be achieved by using genes related to characteristics of economic importance. Considering diversity of plant gene resources in Türkiye, using the identified genes directly will be enormous asset for Türkiye.

The driving forces in dry bean breeding are consumer demand, yield, adaptation, disease-pest resistance, and especially rich nutritional content (Kobal Bekar et al., 2019). All of these breeding criteria are embedded in the genotype of local bean populations. There is a wide variation in beans that will allow selection among the varieties for yield and earliness. Numerous studies were conducted for this purpose, and successful results have been obtained from the development of early and also high-yielding bean varieties (Dreyer ve Wielpütz, 1998).

In some regions of Türkiye, factors such as geographical constraints require agriculture to continue in a way that we can describe as traditional agriculture, where the input is low and the variety is local, mostly for the need for families or local markets. These areas containing local materials (have came to today with natural selection and have stable and suitable taste) are considered a treasure. The breeders need more of these local populations in new variety development studies that take consumer demand into account.

In this study; it was aimed to record descriptive information of local dry bean populations by collecting from different provinces of Türkiye, to determine their agronomic and morphological characteristics, to identify high-yielding local genotypes, to create an infrastructure that can be useful in breeding studies, and to develop varieties suitable especially for semi-arid highland climate conditions. In addition, another purpose was to determine and suggest the appropriate parents for different regions resembling semi-arid highland climate.

2. Material and Methods

As a result of correspondence with the National Seed Genebank of Türkiye, it was determined that there were 24 provinces, including the provinces of Turkish Lakes Region,where material collection has not been thoroughly done yet and local dry bean populations having economic importance are grown. A total of 208 materials were collected for two years in 2017-2018. These materials were collected from provinces/sub-provinces of Isparta (101), Burdur (43), Konya (17), Eskişehir (9), Uşak (6), Karaman (6), Antalya (5), Denizli (4), Çorum (4), Manisa (3), Niğde (2), Kütahya (2), Balıkesir (1), Bolu (1), Bursa (1), Nevşehir (1), Kastamonu (1) and Erzincan (1). The six varieties, Yunus 90, Akman 98, Önceler 98, Akın, and Göynük 98, were used as control group in the experiment. Control cultivars were obtained from the Republic of Türkiye Ministry of Agriculture and Forestry Transition Zone Agricultural Research Institute.

Table 1. Information on the local bean genotypes used in the study

Num	Code	Province	Town	Village	Growth habits
3	ISP3	ISPARTA	ATABEY	-	Dwarf
5	ISP5	ISPARTA	ATABEY	-	Dwarf
13	ISP13	ISPARTA	MERKEZ	GEYRAN	Dwarf
15	ISP15	ISPARTA	MERKEZ	GEYRAN	Dwarf
16	ISP16	ISPARTA	MERKEZ	GEYRAN	Climbing
17	ISP17	ISPARTA	MERKEZ	GEYRAN	Climbing
18	ISP18	ISPARTA	MERKEZ	KÜÇÜKGÖKÇELİ	Dwarf
19	ISP19	ISPARTA	MERKEZ	KÜÇÜKGÖKÇELİ	Dwarf
20	ISP20	ISPARTA	MERKEZ	KÜÇÜKGÖKÇELİ	Dwarf
21	ISP21	ISPARTA	MERKEZ	KÜÇÜKGÖKÇELİ	Dwarf
22	ISP22	ISPARTA	MERKEZ	BÜYÜKGÖKÇELİ	Dwarf
23	ISP23	ISPARTA	MERKEZ	BÜYÜKGÖKÇELİ	Dwarf
28	ISP28	ISPARTA	YALVAÇ	ÇETİNCE	Semi-Dwarf
29	ISP29	ISPARTA	YALVAÇ	ÖZGÜNEY	Climbing
30	ISP30	ISPARTA	YALVAÇ	ÖZGÜNEY	Climbing
31A	ISP31	ISPARTA	YALVAÇ	ÖZGÜNEY	Dwarf
31B	ISP32	ISPARTA	YALVAÇ	ÖZGÜNEY	Dwarf
32	ISP33	ISPARTA	ŞARKİKARAAĞAÇ	YASSIBEL	Semi-Dwarf
33	ISP34	ISPARTA	ŞARKİKARAAĞAÇ	GÖKSÖĞÜT	Semi-Dwarf
34	ISP35	ISPARTA	ŞARKİKARAAĞAÇ	BEYKÖY	Semi-Dwarf
35	ISP36	ISPARTA	ŞARKİKARAAĞAÇ	BEYKÖY	Semi-Dwarf
38	ISP39	ISPARTA	EĞİRDİR	MAHMATLAR	Semi-Dwarf
52	ISP53	ISPARTA	GELENDOST	YEŞİLKÖY	Non-Uniform (S-C)
132	ISP60	ISPARTA	MERKEZ	DEREGÜMÜ	Climbing
136	ISP63	ISPARTA	ATABEY	-	Climbing
176	ISP72	ISPARTA	EĞİRDİR	AĞILKÖY	Dwarf
177	ISP73	ISPARTA	EĞİRDİR	AĞILKÖY	Dwarf
179	ISP75	ISPARTA	ŞARKİKARAAĞAÇ	YASSIBEL	Non-Uniform (D-C)
180	ISP76	ISPARTA	ŞARKİKARAAĞAÇ	YASSIBEL	Climbing
181	ISP77	ISPARTA	ŞARKİKARAAĞAÇ	YASSIBEL	Dwarf
182	ISP78	ISPARTA	ŞARKİKARAAĞAÇ	YASSIBEL	Climbing
185	ISP81	ISPARTA	ŞARKİKARAAĞAÇ	BEYKÖY	Dwarf
189	ISP85	ISPARTA	YENİŞARBADEMLİ	GÖLKONAK	Climbing
194	ISP90	ISPARTA	GELENDOST	YEŞİLKÖY	Climbing
196	ISP92	ISPARTA	GELENDOST	YEŞİLKÖY	Dwarf
197	ISP93	ISPARTA	GELENDOST	YEŞİLKÖY	Climbing
199	ISP95	ISPARTA	ŞARKİKARAAĞAÇ	YASSIBEL	Climbing
202	ISP98	ISPARTA	YALVAÇ	BAHTİYAR	Dwarf
205	ISP101	ISPARTA	MERKEZ	GELİNCİK	Dwarf
67	BUR14	BURDUR	MERKEZ	İLYAS	Dwarf
72	BUR19	BURDUR	MERKEZ	SALA	Climbing
73	BUR20	BURDUR	MERKEZ	KIŞLA	Dwarf
74	BUR21	BURDUR	ÇATAĞIL	-	Dwarf
96	ESK1	ESKİŞEHİR	MERKEZ	-	Dwarf
98	ESK3	ESKİŞEHİR	ALPU	KARAKAMIŞ	Dwarf
99	ESK4	ESKİŞEHİR	ALPU	KARAKAMIŞ	Semi-Dwarf
100	ESK5	ESKİŞEHİR	ALPU	-	Non-Uniform (D-S)
101	ESK6	ESKİŞEHİR	SEYİTGAZİ	SANCAR	Semi-Dwarf
102	ESK7	ESKİŞEHİR	SEYİTGAZİ	SANCAR	Semi-Dwarf
103	ESK8	ESKİŞEHİR	SEYİTGAZİ	KESENLER	Climbing
111	KON1	KONYA	EREĞLİ	-	Semi-Dwarf
115	KON5	KONYA	EREĞLİ	-	Dwarf
145	KON7	KONYA	ILGIN	-	Semi-Dwarf
164	KON15	KONYA	DOĞANHİSAR	YAZIR	Dwarf
165	KON16	KONYA	DOĞANHİSAR	BAŞKÖY	Dwarf
166	KON17	KONYA	BEYŞEHİR	ÜÇPINAR	Non-Uniform (S-S)
119	MAN1	MANİSA	DEMİRCİ	HOŞÇALAR	Semi-Dwarf
123	BRS1	BURSA	YENİŞEHİR	-	Dwarf
125	KÜT1	KÜTAHYA	SİMAV	-	Semi-Dwarf
155	DEN2	DENİZLİ	GÜRSU	-	Dwarf
206	DEN3	DENİZLİ	BOZKURT	HAYRETTİN	Climbing
207	DEN4	DENİZLİ	ÇAMELİ	ARIKAYA	Climbing
170	UŞK1	UŞAK	SİVASLI	PINARBAŞI	Climbing
171	UŞK2	UŞAK	BANAZ	AYRANCI	Semi-Dwarf
172	UŞK3	UŞAK	BANAZ	GÜRLEK	Climbing
173	UŞK4	UŞAK	BANAZ	YENİCE	Climbing
174	UŞK5	UŞAK	BANAZ	AYRANCI	Climbing
175	UŞK6	UŞAK	BANAZ	AYRANCI	Non-Uniform (D-S)

Each population was sown in plots having a length of 5m and 4 rows at the beginning of May 2018 to obtain seeds. Among the 208 materials, those showing climbing-spreading growth habits, severe disease and non-germination were eliminated and 68 of them were selected. Field trials were conducted in 2019-2020 in 4 replications according to the Augmented Experimental Design with 5 control cultivars (Yunus 90, Akman 98, Önceler 98, Akın and Göynük 98) and 68 local beans. The material was evaluated in augmented block design (Federer, 1956). The design consisted of 4 blocks containing 22 genotypes in each with 17 local bean and 5 control cultivars. Sowing was done by hand according to 60 x 10 cm sowing norm in plots (2.4 x 4 m and 4 rows) on May 10 in 2019 and on April 28 in 2020. Basic fertilization was applied with Diammonium Phosphate fertilizer at sowing [130 kg ha^{-1} Diammonium Phosphate (18:46:0)]. Pendimethalin was applied as a pre-emergence herbicide at 3000 ml ha^{-1} to trial plots. In order to ensure the field emergence, irrigation was done once and the plants were irrigated 5 times throughout the study with a drip irrigation system according to the needs of the plants.

The statistical analysis was done using the TARIST, TOTEMSTAT and MSTATC package programs according to the augmented design. LSD (Least Significant Difference); was calculated separately to compare the control cultivars and local genotypes (Peterson, 1994). The following formula was used to compare local genotypes with control cultivars.

$$\text{LSD} = \text{t0.05}\sqrt{\frac{(\text{b}+1).(\text{k}+1).\text{HKO}}{\text{b.k}}} \tag{1}$$

In the above formula; LSD: Least significant difference, HKO: Mean square error, b: Number of blocks; k: Number of control cultivars, t0.05: Two-tailed t-table value.

Isparta province, is located in the center of the Lakes Region; It is in the transition zone between the Mediterranean climate (semi-arid) and the continental climate. The altitude of Isparta is approximately 1050 m. Due to the geographical structure of the region, it has plateau and plain characteristics. For this reason, Lakes Region climate characterized by semi-arid highland climate. According to long-term climate records of Isparta province between April-November, the total precipitation is 275.3 mm, the average temperature is 16.6°C and the average relative humidity is 56.2%. In 2019, when the trial was conducted, it was determined that the average temperature (17.6°C) was higher than the long-term average, the relative humidity (55.8%) was almost the same as the long-term average, and the amount of precipitation (215.5 mm) was lower than the long-term average. In the second year, it is seen that the average temperature (18.9°C) was higher than the long-term average, while the average relative humidity (51.0%) and total precipitation (261.8 mm) were lower than the long-term average (Anonymous, 2021). The soil of experimental area is clayey-loam in terms of texture, calcareous rich (28.7%), poor in organic matter (1.54%), pH 7.66, poor in phosphorus (23.5 mg kg^{-1}) and rich in potassium (176.2 mg kg^{-1}).

3. Results and Discussion

In this study; vegetation period, first pod height, pods per plant, seeds per plant, grain yield, hundred-grain weight, water-uptake capacity and protein ratio characteristics of dry bean genotypes were discussed. These characteristics were examined according to the methods stated by Şener (2021). Means of genotypes and cultivars for vegetation period, first pod height, pods per plant, seeds per plant, seed yield, hundred-grain weight, water-uptake capacity and protein content were given in Table 2 and Table 3. Vegetation period, first pod height, pods per plant, seeds per plant values of dry bean genotypes are provided in Table 2 for 2019 and 2020 year. The differences among bean genotypes were significant for all characteristics examined.

In the first year of the experiment (2019), the average vegetation period ranged from 99.4 to 159.2 days. Among the genotypes, KON16 genotype had the shortest vegetation period, whereas ISP76 genotype had the longest vegetation period (Table 2). Among cultivars, Yunus 90 cultivars (cv.) had the shortest vegetation period with 108.3 days. However, from local genotypes 20 genotypes including ISP3, ISP5, ISP13, ISP15, ISP18, ISP19, ISP20, ISP21, ISP32, ISP73, ISP75, ISP81, ISP101, ESK5, KON1, KON15, KON16, MAN1, KÜT1, and UŞK6 had shorter than Yunus90 for vegetation period.

Table 2. Vegetation period, first pod height, pods per plant, seeds per plant, values of dry bean genotypes

	Vegetation period (day)		First pod height (cm)		Pods per plant (Pods plant^{-1})		Seeds per plant (Seeds plant^{-1})	
Genotype	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
AKIN	143.5	136.0	9.60	8.08	40.72	30.63	108.93	106.88
AKMAN98	120.8	128.5	11.43	8.53	53.20	43.49	196.50	191.31
GÖYNÜK98	118.0	120.3	10.31	8.65	35.70	30.23	122.45	105.35
ÖNCELER90	123.5	115.8	9.07	8.55	30.91	34.20	132.59	112.31
YUNUS90	108.3	124.8	11.00	10.00	27.82	30.80	68.86	82.46
ISP3	101.4	100.7	14.51	11.24	14.87	17.50	50.10	74.18
ISP5	100.4	102.7	12.71	11.84	15.67	16.70	57.30	78.88
ISP13	101.4	108.7	15.21	7.74	19.97	27.90	85.80	120.80
ISP15	101.4	109.7	15.81	9.64	22.36	17.70	82.63	73.88
ISP16	137.4	164.6	13.55	11.14	19.22	89.40	68.19	154.60
ISP17	139.4	137.6	9.36	12.34	20.10	16.70	53.30	67.28
ISP18	101.4	102.7	13.91	12.34	14.07	18.10	44.40	79.88
ISP19	102.4	103.7	10.91	9.74	17.57	18.80	60.20	74.38
ISP20	101.4	101.7	9.21	10.64	15.77	15.20	59.30	64.48
ISP21	101.4	103.7	11.61	10.74	14.97	18.60	43.30	82.28
ISP22	136.4	129.6	7.86	10.54	17.72	33.10	34.30	81.08
ISP23	129.4	103.7	6.81	9.64	17.87	14.80	47.30	67.68
ISP28	130.4	129.6	9.31	9.24	36.67	35.40	159.60	154.20
ISP29	137.4	137.6	9.99	10.54	18.14	22.23	74.63	112.30
ISP30	130.4	167.6	10.21	10.64	56.37	63.00	242.60	175.50
ISP31	110.4	129.6	12.91	10.84	26.77	22.90	68.20	56.88
ISP32	100.4	99.7	13.11	12.64	21.47	16.60	61.90	67.28
ISP33	113.2	106.8	8.66	12.16	28.19	23.15	87.70	98.57
ISP34	115.2	138.9	8.96	7.96	60.92	52.45	268.90	221.40
ISP35	115.2	116.8	11.06	5.56	26.12	30.80	101.30	133.50
ISP36	124.2	130.9	6.86	9.36	32.52	39.15	125.80	174.40
ISP39	138.2	127.8	8.46	11.86	28.62	28.75	74.58	99.37
ISP53	124.2	138.9	10.85	8.96	12.12	23.16	40.98	59.84
ISP60	133.2	138.9	6.86	9.86	32.08	33.65	119.10	131.10
ISP63	158.2	167.9	12.66	8.66	28.72	20.65	50.08	36.67
ISP72	123.2	108.8	10.35	10.76	33.72	29.85	105.90	103.70
ISP73	104.2	109.8	11.26	10.26	13.92	15.85	56.04	65.97
ISP75	102.2	138.9	11.85	7.36	19.52	20.95	65.11	27.57
ISP76	159.2	169.9	10.59	15.66	9.90	14.45	20.23	27.57
ISP77	137.2	131.9	8.34	11.36	14.96	12.45	42.23	47.27
ISP78	137.2	138.9	10.06	9.86	24.82	19.95	69.58	47.57
ISP81	102.2	106.8	15.06	15.76	19.02	21.85	82.98	74.28
ISP85	138.2	139.9	10.95	11.66	11.02	12.85	31.62	40.27
ISP90	114.2	131.9	8.46	10.36	37.62	34.95	134.10	150.30
ISP92	113.0	132.3	10.84	12.62	16.45	16.43	59.14	52.02
ISP93	127.0	132.3	9.47	8.92	10.95	12.81	42.21	44.30
ISP95	136.0	139.3	9.47	13.05	17.62	42.93	55.32	118.40
ISP98	130.0	113.3	10.55	9.02	16.51	29.87	71.98	95.53
ISP101	101.0	100.3	10.64	10.32	14.15	14.63	53.24	53.62
BUR14	109.0	118.3	13.04	9.82	26.35	28.53	94.74	101.10
BUR19	157.0	180.3	9.74	4.42	17.95	26.73	41.44	53.12
BUR20	129.0	132.3	8.24	9.32	15.38	11.13	76.11	44.82
BUR21	110.0	105.3	10.84	11.22	22.28	12.53	74.92	49.62
ESK1	113.0	139.3	11.17	10.72	22.39	11.53	58.76	26.62
ESK3	124.0	113.3	9.34	8.02	36.95	23.93	137.90	84.82
ESK4	123.0	132.3	8.84	9.12	23.39	23.73	76.24	55.72
ESK5	103.0	106.3	11.04	10.92	27.35	19.53	101.50	65.82
ESK6	113.0	132.3	8.84	11.92	37.51	39.43	95.24	111.90
ESK7	123.0	133.3	8.34	8.72	53.56	20.76	165.90	58.53
ESK8	113.0	133.3	8.04	9.14	30.75	23.43	124.80	75.64
KON1	102.0	133.3	9.54	7.12	23.15	31.73	86.14	83.72
KON5	123.4	125.3	15.80	12.58	38.05	21.33	109.90	62.03
KON7	120.4	105.3	7.23	5.95	25.83	25.23	91.01	106.60
KON15	100.4	126.3	12.23	8.88	24.85	19.53	54.88	37.13
KON16	99.4	115.3	13.80	8.18	32.95	24.33	92.29	75.23
KON17	109.4	100.3	10.10	9.48	38.49	27.13	127.50	107.50

**: Significant at P≤0.01 level.

Table 2. Vegetation period, first pod height, pods per plant, seeds per plant values of dry bean genotypes (continued)

	Vegetation period (day)		First pod height (cm)		Pods per plant (Pods plant^{-1})		Seeds per plant (Seeds plant^{-1})	
Genotype	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
MAN1	101.4	101.3	11.80	10.80	37.35	24.63	133.80	87.43
BRS1	109.4	132.3	13.90	9.38	25.45	16.03	76.08	36.53
KÜT1	100.4	134.3	11.20	8.85	21.05	11.34	66.39	23.82
DEN2	113.4	132.3	10.20	9.48	29.15	27.73	108.30	101.40
DEN3	123.4	126.3	8.99	8.48	52.05	29.52	213.50	138.20
DEN4	123.4	126.3	9.99	8.28	53.15	45.23	263.10	215.40
UŞK1	135.4	142.3	9.43	14.28	51.75	49.63	199.30	212.70
UŞK2	111.4	126.3	8.40	7.08	33.05	54.83	141.20	225.60
UŞK3	112.4	126.3	10.20	9.68	33.75	28.13	136.80	106.20
UŞK4	113.4	130.3	10.70	11.58	40.65	47.03	147.20	178.90
UŞK5	110.4	126.3	9.10	7.28	50.95	61.93	193.40	277.10
UŞK6	101.4	132.3	11.20	10.88	19.85	25.03	70.99	105.10
LSD	**7.893**	**16.69**	**1.579**	**0.8061**	**3.143**	**5.430**	**20.14**	**25.81**
CV	**%2.41**	**%4.99**	**%5.74**	**%3.45**	**%3.12**	**%6**	**%5.99**	**%8.07**
F-Value	**76.553****	**6.192****	**10.883****	**23.214****	**286.954****	**30.48****	**151.06****	**74.35****

**: Significant at P≤0.01 level.

In the second year of the experiment (2020), the average vegetation period ranged from 99.7 days in ISP32 genotype to 180.3 days in BUR19 genotype. Among the control cultivars, Önceler98 had the shortest vegetation period with 115.8 days (Table 2). In 2020, even though ISP3, ISP5, ISP13, ISP15, ISP18, ISP19, ISP20, ISP21, ISP23, ISP32, ISP33, ISP72, ISP73, ISP81, ISP98, ISP101, BUR21, ESK3, ESK5, KON7, KON16, KON17, and MAN1 local genotypes had numerically shorter vegetation period than Önceler98, this difference was not significant. The fact that the genotypes showed different responses to different climatic conditions, this is an indication of air temperature having an effect on the vegetation period of the genotypes. In regions where the vegetation period is short; high seed yield is obtained from varieties that are early in terms of germination and flowering. Lower seed yield is obtained from varieties with a long vegetation period (Akçin, 1974). Varieties having less temperature sum requirement flower and mature in a shorter time (Bıyıklı et al., 2021; Soydemir, 2021). Temperature, day length and day length × temperature affect flowering and maturation period (Sepetoğlu, 2002). At the same time, the earliness characteristic is important in terms of growing second crops and crop rotation. Earlier studies showed that the vegetation period was between 63.75 and 149.33 days (Düzdemir, 1998; Pekşen, 2005; Özbekmez, 2015; Serengül, 2019; Taşkesen, 2019; Topal, 2019; Tunalı, 2019; Soydemir, 2021).

The first pod height ranged between 6.81 and 15.81 cm in 2019 and between 4.42 and 15.76 cm in 2020 (Table 2). In 2019, the highest first pod heights were in ISP3, ISP13, ISP15, ISP81, and KON5 local genotypes, and these genotypes did not differ from each other. Among the control cultivars, the highest first pod height (11.43 cm) was in Akman98, and 18 local genotypes (ISP3, ISP5, ISP13, ISP15, ISP16, ISP18, ISP21, ISP31, ISP32, ISP63, ISP75, ISP81, BUR14, KON5, KON15, KON16, MAN1 and BRS1) had higher first pod height than this cultivar (Table 2). In 2020, the highest first pod height was in ISP81 and ISP76 local genotypes. In the same year, Yunus90 cv. had the highest first pod height among the control cultivars with a 10.00 cm however 33 local genotypes (ISP3, ISP5, ISP16, ISP17, ISP18, ISP20, ISP21, ISP22, ISP29, ISP30, ISP31, ISP33, ISP33, IPS39, ISP72, ISP73, ISP76, ISP77, ISP81, ISP85, ISP90, ISP92, ISP95, ISP101, BUR21, ESK1, ESK1, ESK5, ESK6, KON5, MAN1, UŞK1, UŞK4 and UŞK6 genotypes) had higher than its (Table 2). Akın had the lowest first pod height (8.08 cm) among the control cultivars, whereas 10 local genotypes had a lower than its. According to our results, the significant variations was observed among genotypes and years for the first pod height related to genetic and environmental factors. Considering that the first pod height is essential in mechanized agriculture, it can be said that there are promising genotypes in this study. Actually, it has been reported that the first pod height varied between 5.0 and 50.3 cm (Pekşen, 2005; Özbekmez, 2015; Serengül, 2019; Taşkesen, 2019; Topal, 2019; Tunalı, 2019).

The pods per plant ranged from 9.90 to 60.92 in 2019 year. ISP76 and ISP34 genotypes had the lowest and highest value for this trait. Among the control cultivars, Akman98 (53.20) had the highest value and genotypes such as ISP30 (56.37), ISP34 (60.92), and ESK7 (53.56) had higher than Akman98 (P≤0.05; Table 2). Local genotypes including ESK7, DEN3, DEN4, UŞK1, and UŞK5 had similar value with Akman98 (P≤0.05).

The pods per plant ranged from 11.13 to 89.40 in 2020. BUR20 genotype had the lowest pods, while ISP16 genotype had the highest pods. Among the control cultivars, Akman98 had the highest value and genotypes including ISP16, ISP30, ISP34, DEN4, UŞK1, UŞK2, UŞK4, and UŞK5 had higher than Akman98 ($P \leq 0.05$; Table 2). Local genotypes such as ISP36, ESK6, DEN4, UŞK4, and ISP95 had similar value with Akman98 ($P \leq 0.05$; Table 2). The number of pods per plant is an important characteristic for the yield and plant breeding. In this study, it was observed wide variation in number of pods per plant. Some research, number of pods per plant in dry beans varied between 1 and 163 (Çiftçi and Şehirali, 1984; Yorgancılar, 1995; Bozoğlu and Sözen, 2007; Ceyhan et al., 2009; Pekşen, 2005; Varankaya and Ceyhan, 2012; Özbekmez, 2015; Serengül, 2019; Taşkesen, 2019; Topal, 2019; Tunalı, 2019; Soydemir, 2021). Meshram (1977) reported that the most important yield components affecting seed yield of mung beans were grain weight and number of pods per plant and emphasized that these two characteristics should be taken as the most important selection criteria. The determination of local genotypes superior to control cultivars in terms of the number of pods per plant, which is an important feature in terms of yield, will also increase the chances of success in the advanced breeding stages. In research, it was detected that this characteristic is affected by environmental factors. The First flowers of bean have a high pod filling ratio. Therefore, temperature during the flowering period is very significant. The temperature above 23 °C causes low number of pods and seeds per plant (Sepetoğlu, 2002; Adak, 2021). Bozoğlu (1995) reported that environmental conditions affect the number of pods per plant in dry beans. Additionally, Şehirali (1988) and Düzdemir (1998) reported that the number of pods per plant was one of the most important yield components affected seed yield in dry beans was.

The number of seeds per plant of local dry bean genotypes was provided in Table 2 and it varied between 20.23 and 268.9. The lowest number of seeds was in ISP76 (20.23) genotype and the highest number of seeds was in DEN4 (263.1) and ISP34 (268.9) genotypes. Akman98 had the highest number of seeds (196.50), however, 5 local genotypes (ISP30, ISP34, DEN3, DEN4, and UŞK1) had higher than Akman98. Local genotypes such as UŞK5 (193.4), UŞK1 (199.3), and DEN3 (213.5) had similar number of seed with Akman98 ($P \leq 0.05$). In 2020, the number of seeds per plant ranged from 23.82 to 277.1, the lowest and highest values were in the KÜT1 and UŞK5 genotypes, respectively (Table 2). In the second year, Akman98 had the highest value, however 5 local genotypes (ISP34, DEN4, UŞK1, UŞK2, and UŞK5 genotypes) had higher than this cultivar. It was found that some local genotypes had higher seeds than control cultivars. The significant variations were observed related to the genotypes and years for this trait. It was thought that these variations caused by genetic and environmental factors.

The day length, temperature and relative humidity are the most important environmental factors affecting the number of seeds per plant. Temperature above 30 °C and relative humidity below 50% can reduce the number of grain per plant of genotypes, which are not sensitive to the day length (Sepetoğlu, 2002; Akbulut et al., 2014; Adak, 2021). Some researchers reported dry bean was affected by environmental conditions for this trait (Bozoğlu, 1995; Ülker, 2008). Sözen et al. (2014) indicated that the number of seeds per plant of beans is one of the agronomic characteristics that positively and significantly affect the yield. Anlarsal et al. (2000) stated that seed yield positively related to the number of pods, number of filled pods, number of seeds per plant, and seed weight per plant in climbing bean types.

The seed yield is more affected by environmental and agronomic factors. Therefore, the number of pods and seeds per plant should be considered as priority selection criteria in regions where ecology is suitable for bean cultivation (Önder, 1992; Özdemir, 2006; Adak, 2021). The seed per plant ranged from 11.03 to 167.30 (Düzdemir, 1998; Varankaya and Ceyhan, 2012; Serengül, 2019; Topal, 2019). The findings our study, were corresponded with related to researcher.

Table 3. Seed yield, hundred-grain weight, water-uptake capacity, and protein content values of dry bean genotypes

	Seed yield (kg ha^{-1})		Hundred-seed weight (g)		Water-uptake capacity (%)		Protein content (%)	
Genotype	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
AKIN	3885	3769	43.94	43.37	0.473	0.515	21.91	22.57
AKMAN98	4754	5307	26.92	33.52	0.308	0.367	17.25	20.01
GÖYNÜK98	4591	4178	39.73	43.02	0.442	0.475	18.53	19.57
ÖNCELER90	3011	4311	27.91	31.8	0.340	0.383	19.78	22.24
YUNUS90	2212	2954	35.07	43.35	0.413	0.543	19.24	22.18
ISP3	2349	2474	46.13	40.73	0.453	0.422	14.48	18.13
ISP5	2498	3019	45.72	42.06	0.433	0.382	18.42	17.86
ISP13	2067	3759	24.77	35.12	0.233	0.342	17.64	22.34
ISP15	2633	2524	34.41	36.51	0.343	0.282	16.98	22.07
ISP16	2474	6545	37.54	49.69	0.403	0.472	20.26	20.28
ISP17	1429	1920_	47.31	39.58	0.463	0.422	19.41	21.71
ISP18	1789	3224	40.97	43.58	0.413	0.422	17.29	19.81
ISP19	2477	3563	44.10	40.85	0.503	0.462	20.25	19.81
ISP20	2311	2301	39.64	36.80	0.433	0.402	19.48	19.71
ISP21	2217	3555	43.93	43.36	0.443	0.432	21.86	19.07
ISP22	1227	3372	49.96	46.32	0.573	0.562	22.33	23.74
ISP23	1537	2786	33.88	36.17	0.343	0.402	18.93	20.02
ISP28	4415	4069	29.40	35.99	0.283	0.392	17.50	21.59
ISP29	2938	3829	45.22	49.68	0.603	0.482	20.77	23.10
ISP30	4950	3747	18.99	25.48	0.233	0.272	16.29	23.64
ISP31	2683	2378	42.32	44.17	0.453	0.533	18.08	21.96
ISP32	3070	2664	49.81	40.71	0.553	0.472	20.09	19.69
ISP33	2900	3555	31.09	34.77	0.367	0.378	17.14	17.85
ISP34	4828	4602	19.75	23.74	0.207	0.238	16.51	18.78
ISP35	2517	5098	27.89	41.24	0.287	0.468	17.42	24.28
ISP36	3414	5976	31.75	38.77	0.317	0.378	17.76	21.56
ISP39	2506	3773	37.03	43.18	0.387	0.508	19.92	22.09
ISP53	1230	1939	29.52	38.03	0.307	0.468	13.95	21.90
ISP60	3207	3469	26.88	31.53	0.137	0.378	16.76	21.10
ISP63	3156	2986	73.64	84.57	0.617	0.948	20.75	22.15
ISP72	3512	3971	41.26	40.24	0.467	0.438	17.49	21.12
ISP73	2799	2835	48.33	44.19	0.517	0.428	19.22	20.24
ISP75	1838	3403	31.72	33.26	0.407	0.348	16.54	17.88
ISP76	1542	3403	107.30	127.50	1.367	1.469	21.34	22.65
ISP77	1246	1369	32.76	33.59	0.327	0.388	22.01	22.03
ISP78	2625	1644	39.85	43.62	0.437	0.488	21.28	20.46
ISP81	1984	2917	39.28	36.98	0.447	0.398	17.62	22.27
ISP85	1349	2196	48.44	65.31	0.597	0.789	20.18	23.97
ISP90	3195	3268	27.02	28.93	0.227	0.288	20.39	20.98
ISP92	2081	2267	41.28	46.80	0.423	0.502	19.81	20.93
ISP93	1532	1806	43.72	43.05	0.433	0.523	17.11	18.01
ISP95	2130	3982	43.53	49.83	0.443	0.372	22.23	21.79
ISP98	2353	3317	39.31	42.77	0.303	0.523	19.01	19.62
ISP101	1770	1994	40.04	43.58	0.383	0.432	20.45	20.00
BUR14	2962	3807	34.54	45.45	0.393	0.523	17.29	22.79
BUR19	3114	6801	112.80	135.50	1.443	1.483	18.34	20.71
BUR20	2610	1707	34.81	39.47	0.413	0.442	21.57	21.48
BUR21	2953	2283	42.38	44.38	0.513	0.502	20.05	20.62
ESK1	2003	1160	36.65	43.68	0.423	0.513	20.62	22.57
ESK3	3881	2620	33.10	33.01	0.383	0.392	18.92	19.13
ESK4	2125	1977	30.88	40.39	0.343	0.523	18.07	22.24
ESK5	3075	2185	33.28	38.84	0.333	0.482	16.32	19.11
ESK6	2669	5300	33.78	63.85	0.413	0.672	16.46	20.67
ESK7	5970	2618	37.17	51.22	0.443	0.573	16.90	21.03
ESK8	3643	2922	34.53	49.82	0.483	0.502	16.70	21.97
KON1	2549	3061	34.44	43.40	0.423	0.533	16.98	21.29
KON5	4829	3033	44.90	55.82	0.527	0.676	18.88	21.52
KON7	2235	2843	31.42	28.76	0.397	0.316	20.74	18.01
KON15	2315	1603	39.74	44.53	0.357	0.496	19.61	24.56
KON16	4019	3068	40.99	43.54	0.417	0.476	16.80	21.34
KON17	3234	6525	28.74	35.07	0.337	0.396	16.07	21.84

**: Significant at P≤0.01 level.

Table 3. Seed yield, hundred-grain weight, water-uptake capacity, and protein content values of dry bean genotypes (continued)

	Seed yield (kg ha^{-1})		Hundred-seed weight (g)		Water-uptake capacity (%)		Protein content (%)	
Genotype	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
MAN1	4256	3198	37.69	39.28	0.417	0.376	17.26	19.82
BRS1	2497	1135	39.85	36.83	0.437	0.506	19.53	23.33
KÜT1	2149	581	35.22	29.51	0.407	0.406	15.85	20.05
DEN2	3023	2612	33.74	28.80	0.397	0.336	23.15	24.79
DEN3	4349	3886	26.08	33.97	0.237	0.326	18.77	21.42
DEN4	5222	5072	26.92	25.17	0.257	0.236	18.13	18.99
UŞK1	3353	3730	23.40	23.94	0.217	0.256	18.27	20.38
UŞK2	2499	4821	23.36	25.69	0.207	0.266	16.54	20.02
UŞK3	2927	2505	25.28	29.55	0.227	0.316	15.60	20.61
UŞK4	3180	4974	26.03	34.63	0.297	0.346	17.31	20.91
UŞK5	2992	4748	21.83	23.53	0.217	0.306	16.68	20.64
UŞK6	1582	2799	23.38	29.70	0.247	0.296	14.80	20.17
LSD	**51.25**	**48.76**	**6.960**	**5.885**	**0.0845**	**0.08450**	**2.177**	**3.077**
CV	**%5.2**	**%4.45**	**%7.5**	**%5.64**	**%5.81**	**%8.17**	**%4.21**	**%5.4**
F-Value	**125.838****	**88.009****	**32.051****	**27.879****	**36.551****	**17.657****	**17.859****	**5.986****

**: Significant at P≤0.01 level.

In 2019, the seed yield ranged from 1227 to 5970 kg ha^{-1}. The lowest and highest value was determined in ISP22 and ESK7 genotype, respectively. Akman98 had the highest seed yield, whereas 5 local genotypes (ISP30, ISP34, ESK7, KON5, and DEN4) performed better than this cultivar (Table 3). In 2020, the seed yield varied between 581 kg ha $^{-1}$ (KÜT1) and 6801 kg ha $^{-1}$ (BUR19). The genotypes such as ISP16, ISP36, BUR19, and KON17 had higher seed yield than Akman98, while ISP35, ESK6, DEN4, UŞK2, and UŞK4 had similarity with Akman98 (Table 3). İyigün and Kayan (2019) reported that precipitation and temperature affected seed yield. For our study, we can infer that seed yield of genotypes differed between years as precipitation and temperature differed in 2019 and 2020. However, some researcher stated that seed yield of dry beans was affected components such as plant length, number of pods per plant, number of seeds per pod, seed weight, hundred-seed weight, and number of plants per unit area, and these characteristics differed to varieties (Westermann and Crothers, 1977; Önder and Özkaynak, 1994; Yorgancılar et al., 2003; Özbekmez, 2015; Serengül, 2019; Taşkesen, 2019). Additionally, Bozoğlu and Gülümser (1999) determined that seed yield of beans was significant and positive bilateral relations with plant length, number of pods per plant, 1000 seed weight, harvest index, biological yield, seed size index, and flowering period characteristics. In our study, we found that genotypes had higher number of pods per plant, number of seeds per plant, and hundred-seed weight, seed yield. From findings our study, we can infer that some of the local genotypes had promising. Ecological conditions and cultivation practices cause significant variation in yield (Çakır, 2019; Sümbül and Sönmez). Variations in the yield of genotypes vary related to photoperiod response characteristics, temperature, soil and air humidity. Day length and temperature are the main factors that affect bean flowering and fertile pod setting. It recommended that the optimum temperature for bean growth is 18-24 °C, and the relative humidity especially during the flowering period was above 50% (Adak, 2021). In other studies, it was reported that the seed yield of beans is highly affected by genetic structure (Önder, 1992; Önder and Şentürk, 1996; Düzdemir, 1998; Özbekmez, 2015; Serengül, 2019; Taşkesen, 2019). The other researcher reported that genotype, environment, and environment × genotype interaction on seed yield is very significant (Şehirali, 1980; Bozoğlu and Gülümser, 2000). In other studies, seed yield was between 657.0 and 4007.4 kg ha^{-1} (Mishra and Dash 1991; Bozoğlu, 1995; Yorgancılar, 1995; Düzdemir, 1998; Bozoğlu and Gülümser, 2000; Ceyhan et al., 2009; Varankaya and Ceyhan, 2012; Özbekmez, 2015; Serengül, 2019; Taşkesen, 2019; Topal, 2019; Soydemir, 2021).

In 2019, hundred seed weight ranged from 18.99 to 112.8 g. BUR19 genotype had the highest, and ISP30 genotype lowest values. Among the control cultivars, Akman98 (26.92 g) and Akın (43.94 g) had the lowest and highest value. Local genotypes such as ISP3, ISP5, ISP17, ISP19, ISP22, ISP29, ISP32, ISP63, ISP73, ISP76, ISP85, BUR19, and KON5 had higher value than Akın, while ISP21 (43.93 g) and ISP93 (43.72 g) local genotypes had similar.

In 2020, the hundred-seed weight it was between 23.53 (UŞK5) and 135.5 g (BUR19) (Table 3). Akın had the highest value, however, local genotypes including ISP16, ISP18, ISP22, ISP29, ISP31, ISP63, ISP73, ISP76, ISP78, ISP85, ISP92, ISP95, ISP101, BUR14, BUR19, BUR21, ESK1, ESK6, ESK7, ESK8, KON1, KON5, KON15, KON16 had higher than Akın. Aydoğan, (2019) reported that the hundred-seed weight of chickpeas significantly affected by ecological and genetic factors. Additionally, Çancı and Toker (2009) determined that the hundred-seed weight of chickpeas varied depending on environment and sowing date. Anlarsal et al. (2000) detected that there was positive significant relationship between seed yield and hundred-seed weight in dwarf forms of beans. Malhotra et al., 1974 reported that the selections will be successful taking into account the hundred-seed weight, the number of pods plant^{-1}, and the number of seeds per pod. In our experiments, we can say that the variations observed in hundred-seed weight can be one of the criteria to be used in the determination of promising genotypes in the advanced breeding stages. According to the results of our study, the hundred-grain weight shows a wide variation. In other studies, the hundred-grain weight varied between 14.74 and 135.0 g (Çiftçi and Şehirali, 1984; Bozoğlu, 1995; Yorgancılar, 1995; Düzdemir, 1998; Ceyhan et al., 2009; Peksen, 2005; Varankaya and Ceyhan, 2012; Ekincialp and Şensoy, 2013; Özbekmez, 2015; Serengül, 2019; Taşkesen, 2019; Topal, 2019; Tunalı, 2019).

In 2019, BUR19 genotype had the highest (1.443 g) for water-uptake capacity, whereas ISP60 genotype had the lowest values (0.137 g). Akın had the highest water-uptake capacity, however its value was lower than those of 12 local genotypes (ISP19, ISP22, ISP29, ISP32, ISP63, ISP73, ISP76, ISP85, BUR19, BUR21, ESK8, and KON5).

In 2020, the water-uptake capacity varied between 0.236 (BUR19 and ISP76) and 1.483 (DEN4) g. Yunus90 had the highest water-uptake capacity, while local genotypes including ISP22, ISP63, ISP76, ISP85, BUR19, ESK6, ESK7, and KON5 had higher than Yunus90. Yunus90 had similarity with local genotypes such as ISP31, ESK1, and KON1 ($P \leq 0.05$; Table 3). Cengiz (2007) stated that it varied between 0.168 and 0.487 g, whereas Özbekmez, (2015) and Soydemir, (2021) detected that it ranged from 0.146 to 0.809 g. The cooking time of legumes is associate by water-uptake capacity, and varieties with hard seed coats uptake less water than varieties with normal coat hardness (Williams et al., 1986). In addition, it was stated that the hundred-seed weight had a positive relationship with the water-uptake capacity (Karasu, 1993).

The seed protein content ranged from 13.95% (ISP53) to 23.15% (DEN2). Akın had the highest protein content, however this value was lower than those of local genotypes (ISP22, ISP77, ISP95, and DEN2). In 2020, The seed protein content ranged from 17.85% (ISP33) to 24.79 % (DEN2). Akın had lower value than 11 local genotypes (ISP22, ISP29, ISP30, ISP35, ISP76, ISP85, BUR14, ESK1, KON15, BRS1, and DEN2) (Table 3). It thought that this case due to the genetic structure, environmental and agricultural conditions. It has been reported that factors such as genotype, environment (temperature, precipitation, and day-length), cultivation area, soil and climate characteristics, diseases and pests, storage conditions have a strong effect on the technological characteristics of the varieties (Cengiz, 2007). The values obtained from this study ranged within the limits of the previous studies. In other studies, it was reported that the seed protein content ranged from 17.13 to 29.8% (Yorgancılar, 1995; Düzdemir, 1998; Kahraman, 2008; Coelhoa et al., 2009; Varankaya and Ceyhan, 2012; Ghanbari et al., 2013; Özbekmez, 2015; Türkmen, 2020; Soydemir, 2021). As dry bean, which significant food legume crop, has cheap, high in protein content, and digestibility, determination of genotypes with a high protein content is significant.

Conclusion

In this research, phenological observations such as vegetation period, number of pods plant^{-1}, number of seed per plant and hundred-seed weight, etc. have a direct contribution to seed yield, some quality, and technological characteristics particularly seed yield. The many local genotypes had similar performances compared to control cultivars and some genotypes were better than control cultivars. For the number of pods plant^{-1}, number of seeds per plant, and seed yield. It was found that local genotypes such as ISP5, ISP13, ISP18, ISP19, ISP21, ISP22, ISP23, ISP31, ISP32, ISP34, ISP35, ISP72, ISP98, BUR14, BUR20, BUR21, ESK3, KON5, MAN1, DEN2, KON16, and KON17 had better performance than control cultivars. The obtaining promising genotypes that stand out in terms of yield and yield components revealed the importance of this study. Consequently, we can say that these materials have a high potential to be used in advanced breeding levels and variety development studies. The continuing the experiments in the following years may result in developing high-yielding cultivars, high in protein content. Additionally, it is thought that local bean genotypes collected from different regions of Türkiye and wide variations will make a significant contribution to institutions and organizations that carry out breeding research.

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