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Original article

Investigation of the Relationship Between the Pod Properties and Quality Values of Some Bean Varieties

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Abstract

It is important to know the quality values of the products in terms of production and consumption of plant-based foods, and at the same time, it brings the examined product to the forefront in terms of production and consumption. For this reason, 11 commercial bean varieties were grown as the first crop in Kahramanmaraş ecological conditions in 2018, and in this study, it was aimed to examine the relationship between the pod characteristics and quality values of 11 commercial bean varieties. In the study, the correlations between bean cultivars' pod setting time, pod length, grain yield per plant, thousand-seed weight, pod ratio per plant, protein ratio, oil ratio and starch ratio, as well as all correlations between investigated characteristics were also investigated. It was determined that there were statistically significant ($p< 0.01$) differences between bean cultivars in terms of pod setting time, pod length, thousand-seed weight, pod ratio and protein content per plant, and significant ($p< 0.05$) differences in grain yield and oil content per plant. It was noted that there was no significant difference between bean varieties in terms of starch ratio.

Keywords: Bean Quality Values, Correlation Analyze, Phaseolus vulgaris, Protein Ratio, Starch Ratio.

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INTRODUCTION

Hunger and malnutrition are among the most basic vital problems in today's world population is increasing day by day. The high prices of animal-derived food encourage consumers to consume plant-based products in order to meet their protein needs. The limited content of some amino acids in cereal protein makes legumes an alternative protein source (Şehirali, 1988). Beans are in the first place among edible legumes in terms of cultivation area and production in the world. In 2020, dry bean production in the world was realized as 23,546 million tons on an area of 29 million hectares (Anonymous, 2020). In terms of ecology, Turkey is a fertile country where leguminous plants can be grown easily and most legumes are in the position of gene center. Legumes are in second place after cereals in field crop cultivation areas (FAO, 2018). Bean, which is a legume plant, is the most produced plant in Turkey after chickpeas and lentils. InTurkey, 279,518 tons of production was made on 1.029,857 ha area and 271 kg yield was obtained per decare (Anonymous, 2020).

Bean (*Phaseolus vulgaris* L.) is the most important legume plant used in human nutrition in the world. Its cultivation is widespread in temperate regions and it is mostly grown in Asia and South America (Özbekmez, 2015). Bean, which is one of the leguminous plants that constitute the main source of vegetable proteins in nutrition, is widely consumed as dry grain in our country. Bean, which is widely consumed as fresh, canned, fresh grain and dry grain in the world and in our country, is a very important legume plant especially due to the high protein content in its grains. Due to the animal protein deficit in our country, the cultivation of the bean plant, which contains high protein in its grains, is important in closing the animal protein deficit of our country due to the fact that its dry grains contain 23-34% protein, 60% carbohydrates, 5 % crude fiber, 1.7 % fat and 3.6 % ash (Abacı and Kaya, 2018). It is very rich in terms of calcium, potassium, magnesium, phosphorus, iron, manganese and sulfur minerals, as well as vitamins A, B and D in its grains (Pekşen and Now, 2005). Although dry beans are an effective protein source in human nutrition, they fix 64 kg da^{-1} nitrogen to the soil with biological nitrogen fixation (Kün et al., 2005). Due to the nitrogen enrichment of the soil, it meets the nitrogen need of the plant planted after it, and due to these features, it is frequently in crop rotation with other plants (Demircan, 2018).

The cultivation of beans, which can be found in different varieties all over Anatolia, is important due to its importance in human nutrition and its ability to protect the soil. Bean is the most selective edible legume plant in terms of ecological conditions. Bean cultivation, yield and quality in a region are affected by physical factors such as temperature, precipitation, day length, topography, soil type, and biological and socio-economic factors such as diseases and pests (Pekşen, 2005). The production amount of beans, which is cultivated on an area of approximately 25 thousand decares in Kahramanmaraş, is 5 thousand tons (Anonymous, 2017). Cultivating varieties suitable for the ecology of the region and carrying out adaptation studies is an absolute necessity for sustainable agriculture and nutrition, which is our most basic need. Continuity in plant production is only possible with adaptation studies. In this

study, it was aimed to examine the relationship between the pod characteristics and quality values of 11 commercial bean varieties grown as the first crop in Kahramanmaraş conditions.

MATERIALS and METHODS

Commercial bean varieties (Önceler 98, Göynük 98, Yunus 90, Topçu, Aras 98, Alberto, Bermaz, Noyanbey 98, Akman 98, Göksun, Karacaşehir 98) were used as the first crop at Kahramanmaraş Sütçü İmam University Faculty of Agriculture, Department of Field Crops in 2018. Soil properties, saturation, pH, salt (%), lime (%), organic matter (%), potassium (mg/kg), phosphorus (mg/kg) values of the experimental area were 72, 7.66 for 0-30 cm depth 72, 7.66, 0.86, 3.91, 1.66, 53 and 6.29 respectively. The soil sample taken from the experiment area has a clayey structure, high lime content, medium level of available phosphorus (P2O5), and high level of available potassium (K2O). The research was carried out in Kahramanmaraş conditions, which has the effect of Mediterranean climate. The monthly minimum (5.7, 7.5, 11.9, 15.5, 20.0 C0), maximum (25.1, 29.6, 34.7, 37.5, 39.6 C0) mean temperature (14.20, 18.40, 21.70, 25.40, 28.60 C0), mean relative humidity (60.8, 45.3, 52.6, 49.1, 46.2 %) and precipitation (49.0, 46.8, 52.6, 49.1, 46.2 mm) of the months of March, April, May, June, and July, in which the research was conducted in Kahramanmaraş province, which is 568 m above sea level, in 2018, values were recorded (Anonymous, 2018). Before planting, the trial land was plowed with a cultivator, then the cultivator was removed and the trial land was made ready for parcellation and planting. The experiment was sown by hand on March 28, 2018, with 50 cm row spacing and 10 cm in-row spacing. DAP fertilizer was given with the planting. 6 kg of phosphorus was applied per decare. When the plant height was 10 cm, nitrogen fertilizer was applied so that 6 kg of pure nitrogen (N) fell per decare as top fertilizer. Weed control was applied twice as a hand hoe. The water requirement of the plants was met by drip irrigation. Irrigation interval was applied at intervals of 5-8 days by observing the condition of the plant and the soil condition. Harvesting was carried out in the last week of July, when the plants started to dry, by hand-picking.

The pod setting time, pod length, thousand grain weight, grain yield per plant, pod ratio per plant, protein ratio, oil ratio and starch ratio values of the bean varieties used in the experiment and the relationship between these properties were investigated.

The data obtained at the end of the research were analyzed using the SAS statistical program according to the ANOVA method. The means of traits with statistically significant differences were grouped according to Duncan's multiple comparison test ($p< 0.01$).

RESULTS and DISCUSSION

The average values of 11 different bean varieties used in the study, pod setting time, pod length, grain yield per plant, thousand-seed weight, pod ratio, protein ratio, oil ratio and starch ratio and the resulting groups are given in Table 1. There are statistically significant ($p< 0.01$) differences between

bean varieties in terms of pod setting time, pod length, thousand grain weight, pod ratio and protein content per plant, significant ($p< 0.05$) differences in terms of grain yield and oil content per plant. It was noted that there was no significant difference in terms of rate.

Table 1. Average values of bean genotypes of pod setting time, pod length, grain yield per plant, thousand-grain weight, pod ratio, protein ratio, oil ratio and starch ratio.

Genotypes	**PST** (day)**	**PL** (cm)**	**GYPP* (g/plant)**	**TGW** (g)**	**PR** (%)**	**PrR** (%)**	**OR* (%)**	**SR (%)**
Önceler 98	58.00 cd	12.32 a-d	19,57 ab	296.71 dc	53.61 ab	23.193 a-c	2.3050 b-d	46.620
Göynük 98	60.50 bc	12.05 a-d	23,05 a	351.65 b	47.57 bc	22.018 bc	2.2350 b-d	49.928
Yunus 90	61.25 bc	8.02 d	12,47 bc	365.27 ab	32.14 d	23.238 a-c	2.4900 a-d	47.385
Topçu	61.25 bc	14.30 ab	16,27 a-c	241.82 e	39.27 dc	23.090 a-c	2.7200 ab	37.243
Alberto	60.25 bc	9.32 cd	16,60 a-c	361.43 ab	45.43 bc	23.430 ab	2.1675 cd	49.303
Aras 98	56.00 d	8.07 d	10,50 c	283.34 dc	49.93 bc	17.693 d	2.8625 a	49.875
Bermaz	58.50 cd	10.80 b-d	17,87 a-c	300.60 dc	48.46 bc	23.128 a-c	2.0425 d	42.703
Noyanbey98	59.50 bc	11.80 a-d	20,22 ab	386.89 a	52.99 ab	22.090 bc	2.2175 b-d	50.595
Akman 98	59.75 bc	14.62 ab	20,45 ab	303.98 c	46.40 bc	21.863 bc	2.3600 a-d	48.008
Göksun	63.00 b	13.70 a-c	20.00 ab	272.24 de	46.91 bc	20.883 c	2.6950 ab	50.003
Karacaşehir 98	70.25 a	15.77 a	18,70 ab	163.28 f	62.41 a	24.658 a	2.6350 a-c	41.930
CV (%)	**3.51**	**23.33**	**27.32**	**7.23**	**16.33**	**6.46**	**12.97**	**15.49**

PST: Bean Genotypes Of Pod Setting Time, PL: Pod Length, GYPP: Grain Yield per Plant TGW: Thousand-Grain Weight PR: Pod Ratio PrO: Protein Ratio OR: Oil Ratio, SO: Starch Ratio CV: Coefficient of Variation P<0.05 *, P<0.01 **

Pod Setting Time (Day)

The difference between the pod setting times of the bean cultivars included in the experiment was statistically significant at the rate of 1%. It was determined that the time elapsed until 50% pods of the bean varieties used in the experiment varied between 56 days and 70 days. When we compared the pod tying times between varieties, Aras 98 was the variety that completed pod tying in the shortest time with 56 days. This was followed by 98 days and Bermaz varieties. Karacaşehir 98 variety, on the other hand, was found to have the longest pod binding time with 70 days. According to Duncan test, Karacaşehir 98 variety was included in the 1st group (a), Göksun variety was in the second group (b), while Aras 98 variety was included in the last group (d) in the grouping made between the pods obtained from different cultivars (Table 1). According to Anlarsal et al. (2000), which lasted for two years, pod setting times changed between 62.2 and 78.3 days, Yeken et al. (2019) reported that the pod setting times varied between 94.33-120.33 days in 80 bean genotypes, and Özbekmez (2015) in the study conducted with 27 bean genotypes and 5 commercial bean cultivars. It is thought that the differences in the pod setting times, which we found in a shorter time or very close to the results found by previous researchers, may be caused by the differences in the variety factor, climate structure and soil structure.

Length of Pod (cm)

The difference between the pod lengths of the bean varieties included in the experiment was statistically significant at the rate of 1%. It was determined that the pod lengths of the bean varieties used in the experiment varied between 15.77-8.02 cm. When we compared the pod lengths between the cultivars, Karacaşehir 98 cultivar became the cultivar with the longest pod length with 15.77 cm. This was followed by Akman 98 and Topçu varieties with 14.62 cm and 14.30 cm. Yunus 90 and Aras 98

varieties had the shortest pod lengths with 8.02 cm and 8.07 cm. According to Duncan test, in the grouping made between pod lengths obtained from different cultivars, Karacaşehir 98 was in the 1st group (a), Akman 98 and Topçu were in the 2nd group (ab), while Yunus 90 and Aras 98 varieties were included in the last group (d). (Table.1.). In their previous studies, Kumar et al. (2020) found the pod length between 7.6-18.06 cm in their study on 17 bean genotypes, while Bagheri et al.(2015) found an average pod length of 16.07 cm in their study on 9 bean cultivars. Laura et al. (2018) found the pod length between 5.50-26.67 cm in their study on 57 local bean genotypes, and Özbekmez (2015) found the pod length between 6.46-12.78 cm in the study conducted with 27 bean genotypes and 5 commercial bean varieties. Ulukapi and Onus (2014) reported that the pod length ranged between 11-15 cm in their study in which they characterized 12 bean genotypes in terms of morphological and phenotypes, and Pekşen and Smiler (2005) our research findings are similar to previous studies and it is thought that the differences are due to the variety characteristics.

Grain Yield per Plant (g per plant)

The difference between the grain yield per plant of the bean varieties included in the experiment was statistically significant at the rate of 5%. It was determined that the grain yield per plant of the bean varieties used in the experiment varied between 23.05-10.05 g per plant. When we compared the seed yield per plant between cultivars, Göynük 98 cultivar with 23.05 g plant-1 was followed by Akman 98, Noyanbey 98, Göksun, Önceler 98 and Karacaşehir 98 cultivars with 20.4, 20.2, 20.0, 19.5 and 18.7 g per plant with the highest grain yield. Aras 98 variety was the varieties with the lowest number of grain yields with 10.5 g per plant. According to Duncan test, Göynük 98 cultivar is in the first group (a), Akman 98, Noyanbey 98, Göksun, Önceler 98 and Karacaşehir 98 cultivars are in the second group (ab) in the grouping made between the grain yields per plant obtained from different cultivars were included in the last group (c) (Table.1.). In previous studies, the grain yield per plant (Pekşen, 2005), 4.56-14.90 g per plant (Çakmak et al.,1999), 12.21- 15.98 g per plant (Anlarsal et al., 2000) reported that it varies between 7.3-14.3 g per plant as an average of two years in dwarf forms.

Thousand Grain Weight (g)

The difference between the thousand grain weight of the bean varieties included in the experiment was statistically significant at the rate of 1%. It was determined that the thousand grain weights of the bean varieties used in the experiment varied between 386.89-163.28 g. When we compared the thousand-grain weights between the varieties, the Noyanbey-98 variety had the highest thousand-grain weight with 386.89 g. This was followed by the Göynük 98 variety with 351.65 g. The variety with at least a thousand grain weight was Karacaşehir 98 variety with 163.28 g. According to Duncan test, Noyanbey-98 variety was in the 1st group (a), Göynük 98 variety was in the 2nd group (b), while Karacaşehir 98 variety was included in the last group (f) in the grouping made between thousand-grain weights obtained from different cultivars (Draw. 1.). One thousand grain weight in beans is an important

yield factor that directly affects the yield (Bozoğlu, 1995). In previous studies, a thousand grain weight in bean was determined as 182.88 – 407.44 g in Konya ecological conditions Ceyhan (2004), Ülker and Ceyhan (2008) found 249.07 - 455.00 g, Ceyhan et al. (2009) reported that it varies between 218.0 – 467.1 g, Çetin (2020) recorded, 387.81-401.67 g. The results of our research are similar to the results of previous studies.

Pod Ratio in Plant (%)

The difference between the pod ratio of the bean varieties included in the experiment was statistically significant at the rate of 1%. It was determined that the pod rates of the bean varieties used in the experiment varied between 62.41-32.14%. When we compared the pod ratios between varieties, Karacaşehir-98 variety had the highest pod ratio with 62.41%. This was followed by the cultivars Önceler 98 and Noyanbey 98 with the rates of 53.61% and 52.99%, respectively. The variety with the lowest bean ratio was 32.14% Yunus 90. According to Duncan test, Karacaşehir-98 cultivar was included in the 1st group (a), while Önceler 98 and Noyanbey 98 cultivars were in the transitional group (ab), Yunus 90 cultivar was included in the last group (d) in the grouping made between the pod ratios obtained from different cultivars (Table 1)

Protein Ratio (%)

The difference between the protein ratios of the bean varieties included in the experiment was statistically significant at the rate of 1%. It was determined that the protein ratios of the bean varieties used in the experiment varied between 17.69-24.65%. When we compared the protein ratios between varieties, Karacaşehir 98 variety was the variety with the highest protein ratio with a protein ratio of 24.65%. Alberto variety followed this with 23.43% protein ratio. The lowest protein ratio was obtained from Aras 98 variety with 17.69%. According to Duncan's test, in the grouping made between the protein ratios obtained from different varieties, Karacaşehir 98 was in group 1 (a), Alberto variety was in group 2 (ab), while Aras 98 variety was included in the last group (d) in terms of protein ratio (Draw. .). In previous studies, the protein ratio in beans was 19.25 – 23.66% (Cengiz, 2007), 19.51 – 26.60 % (Ülker and Ceyhan, 2008) 18.02-24.8% (Deniz, 2008), 25.56%-28.55 (Dalkılıç,2010), 18.57- 26.80% (Varankaya and Ceyhan, 2011) Güneş (2011), 18.5-30.0%, Kahraman (2014), 28.64-30.89%, Passenger (2020) 18.59-25.22%, Aydoğan et al. (2020) They reported that they found between 19.99-22.50%. The results are in agreement with the results obtained from our research. Many factors such as variety, growing place, soil and climate characteristics, maturation status, storage conditions, phytic acid ratio of the grain, and grain shell thickness affect the quality criteria of legumes (Atli et al. 1994). It is thought that the differences in protein ratio are due to the different varieties used and ecological factors.

Fat rate (%)

The difference between the oil ratios of the bean varieties included in the experiment was statistically significant at the rate of 5%. It was determined that the oil ratios of the bean varieties used in the experiment varied between 2.86-2.04%. When we compared the oil ratios between varieties, Aras 98 variety was the variety with the highest oil ratio with 2.86% oil. Topçu and Göksun varieties followed this with 2.62% and 2.69% oil. The lowest oil content was obtained from Bermaz variety with 2.04%. According to the Duncan test, Aras 98 was in the 1st group (a), Topçu and Göksun varieties were in the second group (ab) in the grouping made between the oil ratios obtained from different cultivars, while the Bermaz variety was included in the last group (d) in terms of oil content (Table 1). In previous literature studies, Cengiz (2007) reported that they found the fat ratios to be between 1.078–1.515%, and Idikut and Karabacak (2020) between 1.02-1.77%. The results obtained from this study and the results obtained by the mentioned researchers have varied between similar limits. Small differences between values are thought to be due to the environmental conditions in which the cultivars were grown.

Starch Ratio (%)

No significant difference was observed between the starch ratios of the bean varieties used in the study. Starch ratios ranged from 41.9% to 50.59%. Noyanbey 98 variety had the highest starch ratio with 50.59%, followed by Göksun variety with 50.00% and the lowest starch ratio was obtained from Karacaşehir 98 variety with 41.9%. In researches on starch ratio in dry bean seeds; Barros and Predencio (2016) reported between 69-72% in Brazil, Rezende et al. (2017) found that it varies between 36-42% in Brazil, and between 46.31% and 40.80% in İdikut and Karabacak 2020). Considering the climatic conditions, environment and application factors, it is seen that our data are within the appropriate limits.

Correlations Between Characteristics

Correlation analysis was performed to reveal the relationship between the characteristics investigated in the study. In the study we conducted with 11 commercial bean cultivars, the correlation relationship between the examined traits is given in Fig.2. According to our findings, there is a positive and significant relationship between pod length and pod setting time (0.6053*), grain yield per plant and pod length (0.6618*), starch ratio and thousand-seed weight (0.6426*). It has been determined that there is a negative and significant relationship between thousand-seed weight and pod setting time (-0.6067*) and thousand-seed weight and pod length (-0.6262*).

Table 2. Correlation coefficients of the relationships between broad bean traits and quality values in bean genotypes.

	PST	**PL**	**GYPP**	**TGW**	**PR**	**PrO**	**OR**	**SO**
PST	1,0000							
PL	**0,6053***	1,0000						
GYPP	**-0,6067***	**-0,6262***	1,0000					
TGW	0,2480	**0,6618***	0,0390	1,0000				
PR	0,3258	0,4434	-0,4355	0,4249	1,0000			
PrO	0,5662	0,3707	-0,1350	0,3516	0,0469	1,0000		
OR	0,2458	0,1328	-0,5856	-0,4922	-0,0662	-0,4517	1,0000	
SO	-0,3598	-0,4322	**0,6426***	0,1073	0,0532	-0,5124	-0,1843	1,0000

PST: Bean Genotypes Of Pod Setting Time, PL: Pod Length, GYPP: Grain Yield per Plant TGW: Thousand-Grain Weight PR: Pod Ratio PrO: Protein Ratio OR: Oil Ratio, SO: Starch Ratio

Knowing the effects of plant characteristics on grain yield will save time and labor in breeding studies (Erman et al., 1997). In study by Peksen et al. (2005), examining the relationships between yield and yield components in some bean genotypes, found that there was a very important correlation between grain yield and pod length (r=0.604**). They reported that the increases in these properties caused a very significant increase in plant grain yield. The highest correlation coefficients in terms of grain yield were determined in the relationships between seed yield per plant and the number of pods per plant, the number of seeds per plant and the length of pods. Similar results were also observed in our findings. In this study, the highest correlation coefficient (0.6618*) was obtained from the relationship between seed yield per plant and pod length. It has been reported that the most important yield factors affecting grain yield in bean are plant height, number of pods, number of grains per pod and 1000 grain weight (Önder and Özkaynak, 1994). Yorgancılar et al. (2003) also reported that the number of seeds per pod, number of leaves per plant, plant height and weight of 1000 seeds should be taken into account, respectively, as criteria that directly affect the yield in terms of variety selection in beans. Bozoğlu and Smiler (1999) determined that there are positive and very important bilateral relations with bean seed yield and the number of pods per plant, biological yield, 1000 seed weight, plant height, harvest index, grain size index and flowering period. The highest positive direct effect on grain yield was obtained from the number of pods per plant, followed by the number of seeds per pod, pod length and 100 seed weight (Pooran-Chand, 1999). In this study, the thousand-grain weight is among the features with the highest correlation coefficient. A significant negative correlation was found between thousand-grain weight and pod setting time (-0.6067*) and pod length (-0.6262*). In this study, it was determined that genotypes with short pod attachment times had shorter pod lengths, but 1000-grain weights were higher than other genotypes. This is thought to be due to the fact that genotypes with short pods have larger grained genotypes.

CONCLUSIONS

In this study, which was carried out with 11 bean varieties in Kahramanmaraş, it was determined that Kahramanmaraş province has a favorable ecology for bean farming due to its seasonal characteristics. As a result of this study, it was determined that Aras 98, Bermaz and Erkenler 98 varieties completed their vegetation period earlier and Göynük 98 variety was the best variety in terms of grain yield per plant. The protein content of Onceler 98, Göynük 98, Yunus 90, Topçu, Alberto and Bernaz cultivars was found to be over 22%. It has been observed that the grain quality criteria of the bean are under the relationship between cultivar characteristics, environmental factors and characteristics. It is hoped that this study will guide further research and contribute to the literature.

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