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*Research article*

# Breeding of Dry Bean Cultivars Using *Phaseolus vulgaris* Landraces in Turkey

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**Abstract.** Yield and yield components is one of the key objectives of the legume breeding program worldwide. Information on these traits is required for the selection of desirable types and efficient utilization of the genetic diversity in dry bean improvement program. Local landraces of dry beans grown over long time period are more resistant to low input growing conditions its genetic and morphologic properties and quality is more acceptable by the growers. From this perspective, 83 dry bean landraces were collected from different bean growing areas of Western Anatolia Region of Turkey in 2015-2016. The dry bean landraces were grown on the experimental farm of Abant Izzet Baysal University, Bolu during 2016 growing season. A single plant from each dry bean landrace was selected according to morphological characterization results and weighted scaling method, and twenty (8 climber and 12 bush types) dry bean lines were accepted as promising. In the present study, yield and yield components of 12 dry bean lines and 2 commercial cultivars were compared in Bolu province under western black sea ecological condition of Turkey. The experiment was arranged in a Randomized Block Design with three replicates in 2017 growing season on the experimental farm of Abant Izzet Baysal University. Emergence percentage (69.50-96.00%), days to flowering 50% (48.00-52.00 days), days to maturity (86.00-107.33 days), plant height (37.20-58.30 cm), height to first pod (12.50-19.00 cm), number of branches per plant (6.25-8.25), number of pods per plant (16.96-41.50 pods), seeds per pod (4.00-6.40 seeds), seed yield per plant (25.41-96.83 g plant$^{-1}$) and 100 seeds weight (29.82-55.35 g) were determined according to IPGRI and EU-CPVO criteria. As a result, lines ÇNK-2, ÇNK-4, YLV-28, YLV-32 and BLCK-7 had superior with respect to yield and yield components and hence selected advanced promising lines will be transferred to regional yield trials required for the official procedures of cultivar registration.

# Türkiye'deki Yerel *Phaseolus vulgaris* Populasyonlarını Kullanarak Kuru Fasulye Çeşitlerinin Islahı

**Anahtar kelimeler:**
Kuru fasulye, yerel popülasyon, seleksiyon, ıslah

**Özet.** Verim ve verim öğeleri dünya çapında baklagil ıslah programının temel hedeflerinden birisidir. Kuru fasulye ıslah programında genetik çeşitliliğin etkin kullanımı ve arzu edilen tiplerin seçimi için bu özelliklere ait bilgilere ihtiyaç duyulmaktadır. Uzun yıllardır yetiştirilen yerel kuru fasulye popülasyonları, düşük girdili yetiştirme koşullarına genetik ve morfolojik özellikleri sayesinde daha dayanıklı ve yetiştiriciler tarafından kalitesi daha kabul edilebilir düzeydedir. Bu amaç doğrultusunda, Türkiye'nin Batı Anadolu Bölgesi'ndeki farklı fasulye yetiştirme alanlarından 83 yerel kuru fasulye popülasyonu 2015-2016 yıllarında toplanmış ve 2016 yılı yetiştirme sezonunda Abant İzzet Baysal Üniversitesi deneme alanında yetiştirilmiştir. Tartılı derecelendirme ve morfolojik karakterizasyon sonuçlarına göre her bir fasulye popülasyonundan tek bitki seçilmiş ve 20 kuru fasulye hattı (8 sarılıcı ve 12 bodur) ümitvar kabul edilmiştir. Bu çalışmada, 12 yerel kuru fasulye hattı ile 2 ticari çeşit verim ve verim öğeleri bakımından Türkiye'nin Batı Karadeniz Bölgesi Bolu ekolojik koşullarında karşılaştırılmıştır. Araştırma, Abant İzzet Baysal Üniversitesi deneme alanında 2017 yılında tesadüf blokları deneme desenine göre üç tekrarlamalı olarak yürütülmüştür. Çimlenme oranı (%69.50-96.00), %50 çiçeklenme gün sayısı (48.00-52.00 gün), olgunlaşma süresi (86.00-107.33 gün), bitki boyu (37.20-58.30 cm), ilk bakla yüksekliği (12.50-19.00 cm), bitkide dal sayısı (6.25-8.25 adet), bitkide bakla sayısı (16.96-41.50 bakla), baklada tane sayısı (4.00-6.40 tane), bitki başına tohum verimi (25.41-96.83 g bitki$^{-1}$) ve 100 tane ağırlığı (29.82-55.35 g) IPGRI ve EU-CPVO kriterlerine göre belirlenmiştir. Sonuç olarak, verim ve verim öğeleri bakımından ÇNK-2, ÇNK-4, YLV-28, YLV-32 ve BLCK-7 üstün ümitvar hatlar olarak seçilmiş ve bu hatların çeşit tescil için bölge verim denemelerine aktarılmasına karar verilmiştir.

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## INTRODUCTION

Among edible legumes crops, dry bean (*Phaseolus vulgaris* L., 2n=2x=22) is a self-pollinated crop species. Beans are globally important crop and appeal both to farmer and consumers. Nearly 50% of grain legumes for direct human consumption in the most of developing countries are dry beans (McClean *et al*., 2004). Beans are staple food for more than 200 million people of sub-Saharan Africa (Schmutz *et al*., 2014). It is the most important crop after chickpea and lentil among the grain legumes in Turkey. Annual bean production exceeds 26 833 394 tonnes in worldwide while production is yearly about 235 000 tonnes in Turkey (FAO 2016). It is protein crop and phaseolin, a seed storage protein, makes up the majority of total seed protein in dry beans (Madakbaş *et al*., 2014).

*Phaseolus vulgaris* L. was independently domesticated in present day north Mexico and Andes mountains to northwest Argentina around 8000 years ago (Gepts and Debouck 1991; Mamidi *et al*., 2011; Blair *et al*., 2012; Bitocchi *et al.,* 2013). Mesoamerican gene pool originated from Mexico to Columbia, while Andean gene pool domesticated in from south Peru to Nothwestern Argentina (De la Fuente *et al*., 2012). Domestication of cultivated common at two independent regions such as Mesoamerican and Andean zones, endowed the crop relatively high diversity (Gepts and Debouck 1991; Gepts 1998). Beans are believed to have been brought together with maize to Mediterranean coast by Portuguese and Spanish traders in the 16$^{th}$ and 17$^{th}$ century (Greenway 1945; Gentry 1969) and then introduced to Anatolia in the 17th century (Bozoğlu *et al*., 2011). Varying geography, different climatic regions and natural selection for organoleptic requirements over this period created rich bean diversity of landraces in Anatolia (Madakbaş *et al*., 2014).

Productivity, seed quality, seed mineral contents, and resistance to biotic and abiotic stress and many other traits are important plant traits for future bean breeding in order to meet ever increasing global food demand. In order to increase the efficiency of selection, maximum use of natural genetic diversity is one of the most critical and significant objectives of crop improvement program.

Dry bean landraces, which have been cultivated in different regions for many years, have various characteristic traits as a result of spontaneous mutations. Assessing these differences, identification of dry bean germplasm containing high yield and yield components is crucial for dry bean breeding. Earlier work by Çiftçi *et al.* (2009) selected common bean genotypes of early maturity, high yield potential and salt resistance from landraces from Van-Gevaş. 23 genotypes were selected by weighed ranking method on the basis of selection criteria among 75 genotypes on the bases of phenological and morphological properties as days to maturity, seed yield per plant, pod lengths, 1000 seeds weight of selected types were found as 103-140 days, 119.28-9.59 g plant$^{-1}$, 11.04-23.10 cm and 278.29-681.89 g, respectively. In another study, a collection of 418 bean landraces collected North East Anatolia and Çoruh Valley were evaluated in characterization and selection work in Erzurum in 2008, 2009 and 2010 selecting high yielding dry bean landraces for the field conditions. On the bases of germination days, days to flowering, plant height, number of branch per plant, number of pods per plant, height to first pod, seeds per pod, days to maturity, 1000 seeds weight of genotypes were detected as 13-16 days, 38-92 days, 37-118 cm, 1.0-5.6 pieces, 1.2-27.0 pods plant$^{-1}$, 6.4-15.0 cm, 1.0-6.2 seeds, 113-120 days, 219.0-1003.4 g in 2008, respectively (Kantar *et al*., 2010). As part of another study, Çiftçi *et al*. (2012) collected and evaluated 414 bean genotypes from the South of Eastern Anatolia provinces selecting a total of 4 landraces for dry consumption and 38 for fresh consumption. On the basis of emergence percentage, days to flowering, days to first pod, days to maturity, pod height were determined as 10-100%, 49-67 days, 55-98 days, 78-161 days, 8.38-24.61 cm.

Dry beans production is a household activity in all regions and there are many dry bean landraces unique to each region in Turkey. The effective use of the local gene resources is very important for breeding studies. The aim of this work was to select advanced dry bean (*Phaesolus vulgaris* L.) lines. Selected dry bean lines will be transferred to advance yield experiments for registration and production permit according to national rules.

## MATERIALS AND METHODS

### *Plant Materials*

Eighty-three dry bean landraces were collected from farmers' fields of different provinces (Düzce, Kocaeli, Yalova, Bilecik, Bursa, Balıkesir, Çanakkale) of Turkey from October 2015 to March 2016. Morphological and agronomic characterization of these 83 dry bean landraces were performed according to the cultivar evaluation criteria developed by IPGRI (International Plant Genetic Resources Institute) and EU-CPVO (European Union Community

Plant Variety Office) on the experimental farm of Abant Izzet Baysal University, Bolu during 2016 growing season. A single plant from each dry bean landrace was selected according to morphological characterization results and weighted scaling method. Twenty (8 climber and 12 bush types) dry bean lines were regarded as promising.

Twelve promising lines (YLV-28,32, BLKSR-3,4, BRS-3,21,22, BLCK-7 and ÇNK-2,4,6,8) (Figure 1 and 2) with two commercial cultivars (Önceler-98 and Göynük-98) were compared in this experiment (Table 1).

**Table 1.** Passport data of dry bean landraces collected from Northwestern Turkey.
*Çizelge 1. Türkiye'nin kuzey batısından toplanılan kuru fasulye popülasyonlarının pasaport bilgileri.*

| Landraces Number | Names of Landraces | Collection Site | District | Village | Altitude (m) | Coordinates |
|---|---|---|---|---|---|---|
| 1 | YLV-28 | Yalova | Merkez | Kurtköy | 362 | 40°33'12.70"N/29°12'52.17"E |
| 2 | YLV-32 | Yalova | Merkez | Sugören | 428 | 40°33'38.32"N/29°19'34.07"E |
| 3 | BLKSR-3 | Balıkesir | Manyas | Salur Mh. | 29 | 40° 5'58.61"N/27°56'16.65"E |
| 4 | BLKSR-4 | Balıkesir | Manyas | Akçaova Mh. | 30 | 40° 7'16.68"N/27°51'15.26"E |
| 5 | BRS-3 | Bursa | Yenişehir | Osmaniye | 377 | 40°10'18.45"N/29°37'15.12"E |
| 6 | BRS-21 | Bursa | Kestel | Kozluören | 496 | 40° 7'39.19"N/ 29°21'9.43"E |
| 7 | BRS-22 | Bursa | Kestel | Aksu | 360 | 40°10'2.02"N/ 29°18'58.01"E |
| 8 | BLCK-7 | Bilecik | Pazaryeri | Dereköy | 813 | 39°59'12.52"N/ 29°51'7.17"E |
| 9 | ÇNK-2 | Çanakkale | Yenice | Çınarcık | 320 | 39°57'6.22"N/ 27°10'54.75"E |
| 10 | ÇNK-4 | Çanakkale | Biga | Aşağıdemirci | 58 | 40°14'38.70"N/ 27°22'17.65"E |
| 11 | ÇNK-6 | Çanakkale | Biga | Gerlengeç | 25 | 40°17'26.36"N/ 27°25'14.56"E |
| 12 | ÇNK-8 | Çanakkale | Bayramiç | Beşik | 306 | 39°44'15.48"N/ 26°41'34.82"E |
| 13 | Göynük 98 | Registered Cultivar | | | | |
| 14 | Önceler 98 | Registered Cultivar | | | | |

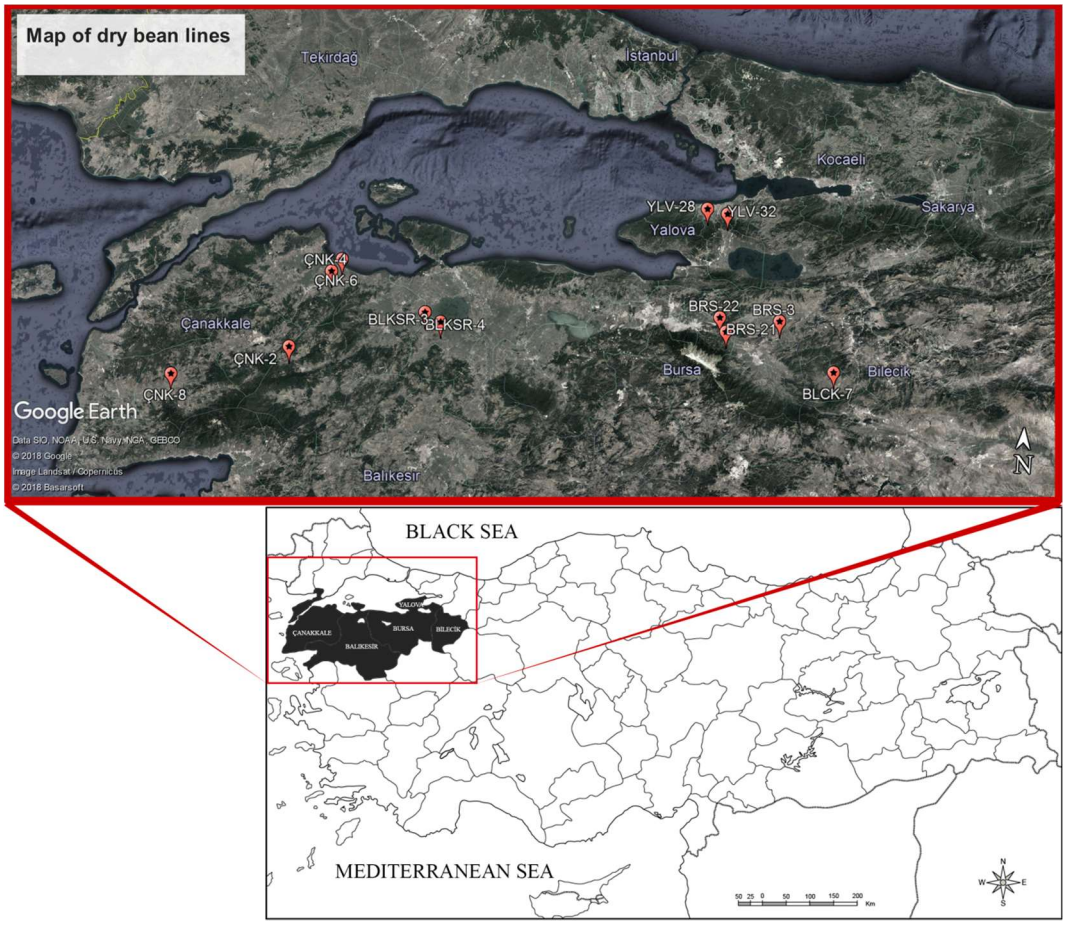


**Figure 1.** Map of North West of Turkey from which dry bean landraces were collected. Provinces where landraces were collected were marked in red.
*Şekil 1. Türkiye'nin kuzey batısından toplanılan kuru fasulye populasyonlarının haritası. Fasulye popülasyonlarının toplandığı iller kırmızı ile işaretlenmiştir.*


**Figure 2.** Seeds of dry bean (*Phaseolus vulgaris* L.) lines used in the study.
*Şekil 2. Çalışmada kullanılan yerel kuru fasulye (Phaseolus vulgaris L.) hatlarının tohumları.*

### *Climate Conditions*

The altitude of the experimental site from sea level is approximately 754 m and located at 31°37' E and 40°44' N. The growth period in 2017 after sowing had relatively higher rainfall in comparison to the long term average of last sixteen years' average (Table 2). Average temperature in growing period was similar to long term climate data. However, Table 2 reveals that total precipitation in July 2017 (1.6 kg $m^{-2}$) was lower than that of the long term average (30.4 kg $m^{-2}$). Consequently, the year 2017 was an exceptionally drier year.

### *Crop Sowing and Experimental Design*

The experiment was arranged in randomized block design with three replicates in 2017 growing season on the experimental farm of Abant Izzet Baysal University, Bolu, Turkey. The bean lines were sown on 1st of May 2017 in the plots consisting two rows of 4 m long with row spacing of 45 cm and intra row spacing of 10 cm. A fertiliser rate of 4 kg of nitrogen and 6 kg of phosphorous were given at the time of sowing in the form of ammonium sulphate and triple super phosphate. Standard agricultural practices were applied equally in all the plots.

### *Yield and Yield Components*

Dry bean lines were evaluated according to IPGRI and EU-CPVO on five plants from each plot. Emergence percentage (EP), days to flowering 50% (DF), days to maturity (DM), plant height (PH), height to first pod (HFP), number of branches per plant (BN), number of pods per plant (P/P), seeds per pod (SPP), seed yield per plant (SY) and 100 seeds weight (SW) were recorded on plots (Anonymous 2009).

### *Statistical Analysis*

The data were analyzed using Analysis System computer software (SAS Version 9.0). Means values were separated according to *Least Significant Difference* (LSD) test at p=0.05.

**Table 2.** Monthly total precipitation, temperature and relative humidity in 2017 and long term average (2000-2016).
*Çizelge 2. 2017 yılı ve uzun yıllar ortalaması (2000-2016) aylık toplam yağış, sıcaklık ve nisbi nem.*

| **2017** | | **May** | **June** | **July** | **August** | **September** |
|---|---|---|---|---|---|---|
| Average Temperature | °C | 12.8 | 17.4 | 20.6 | 20.0 | 17.5 |
| Total Precipitation | kg $m^{-2}$ | 74.1 | 64.8 | 1.6 | 39.6 | 4.4 |
| Average Relative Humidity | % | 74.7 | 73.3 | 65.8 | 70.1 | 65.3 |
| **2000-2016** | | **May** | **June** | **July** | **August** | **September** |
| Total Precipitation | kg $m^{-2}$ | 58.7 | 52.1 | 30.4 | 24.4 | 27.3 |
| Average Temperature | °C | 14.1 | 17.5 | 19.9 | 19.7 | 16.1 |

## RESULTS AND DISCUSSION

### *Emergence Percentage*

Significant differences were found among bean lines in terms of emergence percentage (EP) ($p<0.05$) (Table 3). The average EP was observed as 81.68% of bean lines. The highest EP was seen in BLKSR-4 (96%) and followed by ÇNK-4 (89%), the lowest EP was determined in BRS-22 (69.5%). EP of commercial cultivars (Önceler-98 and Göynük-98) was found as 85% and 70%, respectively. While EP of Önceler-98 was observed as lower than 3 lines (ÇNK-4,8 and BLKSR-4), Göynük-98 was only seen to be higher than BRS-22. In previous studies, variations in bean genotypes can be seen in terms of the cardinal temperature requirement for germination and emergence. Genotypes with a low cardinal temperature requirement emerged in a shorter time (Wagenvoort and Bierhuizen 1977; Kantar and Elkoca 2001). It was reported that no germination was seen under 10°C and above 35°C and under extreme conditions (Demir and Yanmaz 1994; Sehirali 2002; Balkaya 2004; Kurtar *et al*., 2004). The average temperature was recorded as 12.8°C in May of 2017 and affected positively to germination.

### *Days to flowering (50%)*

Days to flowering 50% (DF) recorded in the field of the lines investigated were regarded as early, medium and late flowering, 45, 50 and >50 days, respectively (Balkaya and Yanmaz 2003; Madakbas *et al*., 2009; 2010; Düzdemir and Ece 2010; Madakbaş and Ergin 2011). No significant variations were recorded among the lines in DF (Table 3). With regard to DF, Göynük-98, YLV-32 and BRS-22 were determined as late flowering, and the rest of the lines (ÇNK-2,4,6,8; BLCK-7; YLV-28; BLKSR-3,4; BRS-3,21) were observed as medium flowering (Table 3). ÇNK-8, BRS-21 and BLKSR-3 were detected as the early lines with 48 days. These values are within the range reported by early works done with lines (Çiftçi 2009; Kantar 2010; Fivawo and Msolla 2011; Madakbas and Ergin 2011; Sofi *et al*., 2011; Aydoğan 2017).

### *Days to Maturity*

Significant differences were observed among bean lines in terms of days to maturtiy (DM) ($p<0.05$). The average DM for all lines recorded was 97.95 days with the highest DM being in YLV-32 (107.33 days) and the lowest being in ÇNK-8 (86 days) followed by BRS-21, BLKSR-3 (Table 3). DM of ten lines (ÇNK-2,4,6,8; BRS-3,21,22; BLKSR-3,4; YLV-28) were earlier than commercial cultivars (Önceler-98 and Göynük-98). A study reported that days to flowering and maturity can be influenced by environmental factors such as temperature and photoperiod (Rana *et al*. 2015). Bozoğlu and Sözen (2007) and Güneş (2011) reported DM values of 73-170, 99-135 days for lines. DM values recorded in our experiment are within the range of early works done (Çiftçi 2009; Kantar 2010; Fivawo and Msolla 2011; Sofi *et al*., 2011; Aydoğan 2017; Yeken 2017).

### *Plant Height*

High variability was recorded for plant height (PH) ranging from 37.20 to 58.30 cm amongst bean lines ($p<0.05$). PH was the highest (58.30 cm) for Göynük and the shortest (37.20 cm) for ÇNK-8 with an average value of 49.23 cm (Table 3). PH values of lines varied with environmental conditions (Bozoğlu 1995; Pekşen 2005; Ülker 2008). Although PH in bean has high heritability degree (84.6-90.0%) (Çiftçi and Şehirali, 1984). In other studies, significant variations were recorded for PH (Bozoğlu and Sözen 2007; Ceyhan *et al*., 2009; Çiftçi 2009; Kantar 2010; Fivawo and Msolla 2011; Sofi *et al*., 2011; Yeken 2017).

### *Height to First Pod*

Height to first pod (HFP) is one of the most important parameters for the mechanical harvesting. The varieties, which have high HFP), can be harvested by machine (Elkoca and Çınar 2015). It was seen that HFP had significant differences among bean lines in Table 3 ($p<0.05$). While the highest HFP was recorded in ÇNK-2 (19.0 cm), the lowest was determined in YLV-28, 32 (12.5 cm), and the average HFP was being 15.39 cm. With regard to HFP, eight lines (ÇNK-2,4,8; BRS-3,21,22; BLKSR-4; BLCK-7) were detected as higher than commercial cultivars. In previous studies, it is reported that HFP showed high significant variation ranging from 6.9 cm to 29.3 cm amongst bean lines (Bozoğlu 1995; Anlarsal et al., 2000; Düzdemir ve Akdağ 2001; Pekşen 2005; Elkoca and Çınar 2015).

### *Number of Branches Per Plant*

The statistical analysis of data on number of branches per plant (BN) showed remarkable differences ($p<0.05$) among bean lines (Table 3). The mean BN was 7.51 pieces, and it ranged from 6.25 pieces for BRS-21 to 8.25 pieces for ÇNK-2. Özçelik and Gülümser (1988) found the BN as 7.4-9.0 in their study, which investigated on yield and yield components of 10 common bean genotypes in Samsun ecological conditions of Turkey. Another study reported that

yield, yield components and technological characteristics of some dry beans genotypes were determined in Ordu ecological conditions, and BN was in the range of 3.03-5.33 33 (Özbekmez 2015). Other researchers reported that there are significant differences between years in terms of BN as a consequence of climatic differences (Karakuş *et al*., 2005; Pekşen 2005; Elkoca and Çınar 2015).

***Number of Pods Per Plant***

There were statistically ($p$<0.05) significant differences among bean lines terms of number of pods per plant (P/P) with, the values ranging between 16.96 and 41.50 pods plant$^{-1}$ and the highest being BLCK-7 and lowest being BRS-21 (Table 3). The average P/P was 25.13 pods/plants. With regard to P/P, seven lines (ÇNK-2,4; BRS-3; BLKSR-4; BLCK-7; YLV-28,32) were higher than commercial cultivars. P/P was reported as 4.5-25.0 pods plant$^{-1}$ by Peşken and Gülümser (2005) and 17.9-58.0 pods plant$^{-1}$ by Yıldız (2015). Tıkka and Kumars (1976) reported that P/P is one of the most important factors which directly affect yield. Another study noted that increasing P/P and SPP can increase plant yield (Yılmaz *et al*., 2014). Many previous studies indicated that direct effect of P/P on seed yield was positive and significant (Rodrigo *et al*., 1972; Sehirali 1980; Dhiman 1996; Pooran-Chand 1999; Amini *et al*., 2002). P/P in our study was in the range reported by previous studies (Çiftçi 2009; Yıldız 2015; Aydoğan 2017).

***Seeds Per Pod***

Table 3 indicates that seeds per pod (SPP) varied significantly ($p$<0.05) among bean lines. Mean, lowest and highest values of bean lines were 4.71, 4.00, and 6.40 seeds, respectively. Three lines (BRS-21,22; BLKSR-3) were higher than commercial cultivars in terms of SPP (Table 3). SPP of 4274 common bean accessions in the Indian hill region were observed between 4-8 seeds by Rana *et al*. (2015). Furthermore, some researchers reported that SPP varied between 2.10-9.60 seeds depends on ecological conditions (Bursa, Erzurum, Samsun, Konya, Yozgat, Ordu and Van-Gevaş) and genetic diversity (Azkan and Yürür 1987; Elkoca and Kantar 2004; Pekşen 2005; Ülker and Ceyhan 2008; Çiftçi 2009; Fivawo and Msolla 2011; Nechifor *et al*., 2011; Sofi *et al*., 2011; Varankaya 2011; Özbekmez, 2015; Aydoğan 2017).

***Seed Yield Per Plant***

Seed yield per plant (SY) is the most important traits for crop plants. Statistically significant differences ($p$<0.05) were observed of beans lines in this study. The average SY was 49.50 g plant$^{-1}$ (Table 3) with the lowest SY being in ÇNK-8 (25.41 g plant$^{-1}$), and the highest value BLCK-7 (96.83 g plant$^{-1}$) followed by YLV-32. BLCK-7, YLV-28,32, ÇNK-2,4,6, BRS-3 and BLKSR-4 had the highest SY of the lines, being higher

**Table 3.** Plant Growth Data of dry bean lines in comparison with commercial cultivars and LSD groups.
*Çizelge 3. Yerel kuru fasulye hatlarının bitki büyüme verilerinin ticari çeşitlerle karşılaştırılması ve LSD grupları.*

| | EP | DF | DM | PH | HFP | BN | P/P | SPP | SY | 100 SW |
|---|---|---|---|---|---|---|---|---|---|---|
| **BLCK-7** | **78.50 bcd** | **50.00** | **103.03 bc** | **55.24 ab** | **15.50 b-e** | **8.00 ab** | **41.50 a** | **4.40 de** | **96.83 a** | **54.53 a** |
| BLKSR-3 | 85.00 abc | 48.00 | 86.67 f | 52.50 bc | 14.00 ef | 7.60 ab | 18.25 de | 6.40 a | 35.17 def | 32.01 gh |
| BLKSR-4 | 96.00 a | 49.00 | 98.63 de | 47.00 de | 15.00 c-f | 6.50 cd | 25.65 cd | 4.70 cd | 47.37 cde | 42.35 bc |
| BRS-3 | 80.50 bcd | 49.00 | 98.53 de | 49.90 cd | 18.00 ab | 8.00 ab | 29.99 bc | 4.20 ef | 48.80 cd | 36.91 def |
| BRS-21 | 79.50 bcd | 48.00 | 86.47 f | 44.60 e | 17.00 a-d | 6.25 d | 16.96 e | 5.50 b | 35.31 def | 36.47 ef |
| BRS-22 | 69.50 d | 51.00 | 98.53 de | 43.80 e | 14.50 def | 7.00 bcd | 19.53 de | 4.90 c | 38.13 def | 40.84 cd |
| **ÇNK-2** | **81.50 a-d** | **49.00** | **97.03 e** | **52.70 bc** | **19.00 a** | **8.25 a** | **29.29 c** | **4.70 cd** | **58.09 c** | **45.16 b** |
| **ÇNK-4** | **89.00 ab** | **49.00** | **96.27 e** | **48.60 cde** | **17.50 abc** | **8.20 a** | **25.22 cd** | **4.20 ef** | **55.06 c** | **51.29 a** |
| ÇNK-6 | 83.00 a-d | 50.00 | 97.33 e | 52.50 bc | 14.00 ef | 7.50 abc | 22.17 cde | 4.60 cd | 40.40 de | 39.24 cde |
| ÇNK-8 | 87.50 abc | 48.00 | 86.00 f | 37.20 f | 17.00 a-d | 7.83 ab | 18.89 de | 4.60 cd | 25.41 f | 29.82 h |
| **YLV-28** | **85.00 abc** | **49.00** | **98.53 de** | **43.80 e** | **12.50 f** | **7.85 ab** | **24.40 cde** | **4.70 cd** | **57.94 c** | **52.57 a** |
| **YLV-32** | **73.5. cd** | **52.00** | **107.33 a** | **55.13 ab** | **12.50 f** | **7.00 bcd** | **38.00 ab** | **4.00 f** | **80.54 b** | **55.35 a** |
| Göynük-98 | 70.00 d | 52.00 | 106.00 ab | 58.30 a | 14.50 def | 7.25 a-d | 18.83 de | 4.10 ef | 34.38 ef | 45.51 b |
| Önceler-98 | 85.00 abc | 49.00 | 101.57 cd | 47.90 cde | 14.50 def | 7.87 ab | 23.19 cde | 4.88 c | 39.55 de | 34.49 fg |
| Average | 81.68 | 49.50 | 97.95 | 49.23 | 15.39 | 7.51 | 25.13 | 4.71 | 49.50 | 42.61 |
| F value | 2.06* | 0.90 | 22.78* | 11.41* | 4.02* | 2.81* | 6.94* | 24.09* | 16.84* | 33.93* |
| CV % | 10.82 | 4.96 | 2.52 | 5.92 | 11.28 | 8.58 | 19.35 | 4.68 | 16.58 | 5.87 |
| LSD (0.05) | 14.83 | | 4.11 | 4.89 | 2.91 | 1.08 | 8.16 | 0.37 | 13.77 | 4.20 |

*: $P \leq 0.05$, EP: Emergence percentage, DF: Days to flowering 50%, DM: Days to maturity, PH: Plant height, HFP: height to first pod, BN: Number of branches per plant, P/P: Number of pods per plant, SPP: Seeds per pod, SY: Seed yield per plant and SW: 100 seeds weight.

than commercial cultivars (Table 3). Eberhart and Russell (1966) reported that an ideal variety combines high yield with stability of performance. Researchers reported that among various traits, seed traits were the most crucial in common bean varieties (Park *et al*., 2000; Bisht *et al*., 2014; Rana *et al*., 2014; 2015). Seed traits were greatly heritable (Singh *et al*., 2007; Blair *et al*. 2010). According to Çiftçi *et al*. (2009), SY of selected types were detected to vary between 9.59-119.28 g plant$^{-1}$ at Van-Gevaş in 2008. Similar observations on SY were determined in other studies (Sözen 2012; Özkorkmaz Atıcı 2013).

***100 seeds weight***

100 seeds weight (SW) significantly varied ($p<0.01$) among bean lines ranging from 29.82 to 55.35 g (Table 3). The average SW was 42.61 g. With regard to SW, four lines (YLV-28,32; BLCK-7; ÇNK-4) were higher than commercial cultivars. Several researchers reported that seed weight was associated positively with various other yield traits in bean germplasm (Blair *et al*., 2006; Rai *et al*., 2006; Dursun 2007; Apostolova *et al*., 2009; Bhushan *et al*., 2009; Kumar *et al*., 2009; Karasu and Oz 2011; Sofi *et al*., 2011; Ahmed and Kamaluddin 2013; Sofi *et al*., 2014). The other studies noted that SW ranged between 3.5-96.3 g and 42.2-60.3 g in the genotypes by Rana *et al*., (2005) and Aydoğan (2017). Roy *et al*. (2006), Fivawo and Msolla (2011), Nechifor *et al*. (2011), Sofi *et al*. (2011), Ahmad and Kalamuddin (2013) and Ali *et al*. (2016) reported also same range values for 100 seeds weight.

## CONCLUSIONS

Dry bean lines were compared with commercial cultivars according to IPGRI and EU-CPVO in the study in terms of emergence percentage, days to flowering 50%, days to maturity, plant height, height to first pod, number of branches per plant, number of pods per plant, seeds per pod, seed yield per plant and 100 seeds weight. Among the commercial cultivars and lines investigated, BLCK-7 and YLV-32 were statistically significantly superior in terms of seed yield per plant (96.83 g plant$^{-1}$ and 80.54 g plant$^{-1}$) and number of pods per plant (41.5 pods plant$^{-1}$ and 38 pods plant$^{-1}$). Among lines investigated in the experiment, BRS-21, BLKSR-3 and ÇNK-8 were of early maturation period. However, these lines were lower than other lines in terms of seed yield per plant (35.31, 35.17 and 25.41 g plant$^{-1}$) and number of pods per plant (16.96, 18.25 and 18.89 pods plant$^{-1}$). On the other hand, ÇNK-2, ÇNK-4 and YLV-28 were higher than commercial cultivars (Önceler-98 and Göynük-98) and other lines (ÇNK-6,8; BRS-21,22; BLKSR-3) in terms of seed yield per plant (58.09, 55.06 and 57.94 g plant$^{-1}$) and number of pods per plant (29.29, 25.22 and 24.40 pods plant$^{-1}$). In conclusion, lines of ÇNK-2, ÇNK-4, YLV-28, YLV-32 and BLCK-7 had superior yield and yield components for variety registration and commercialization.

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