Journal of Agricultural Sciences
(Tarim Bilimleri Dergisi)

J Agr Sci-Tarim Bili
e-ISSN: 2148-9297
jas.ankara.edu.tr

JAS

Determination of the Seed Yield and Quality Characteristics of Some Advanced-Generation Field Pea (*Pisum sativum* L.) Lines

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ARTICLE INFO
Research Article
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Received: 12 August 2021 / Revised: 04 March 2022 / Accepted: 07 March 2022 / Online: 18 January 2023

Cite this article
ŞENBEK G, HALİL D S, UZUN A, AÇIKGÖZ E (2023). Determination of the Seed Yield and Quality Characteristics of Some Advanced-Generation Field Pea (*Pisum sativum* L.) Lines. *Journal of Agricultural Sciences (Tarim Bilimleri Dergisi),* 29(1):142-148. DOI: 10.15832/ankutbd.981778

ABSTRACT
This study was conducted to determine the seed yield, yield components, and seed quality values of some field pea genotypes grown under Bursa ecological conditions. The trials were carried out at Bursa Uludag University, Faculty of Agriculture, Agricultural Research and Application Center in the years 2013-2014 and 2015-2016. The present study was conducted with three replications according to the randomized complete block design. The 7 pea lines (PS1, PS2, PS3, PS4, PS5, PS6, PS7) and Golyazi cultivar were used as the plant material. These lines were obtained as a result of the hybridization studies that were started in 2007. The Golyazi cultivar, which was developed by Bursa Uludag University, Faculty of Agriculture, Department of Field Crops, was used as the control cultivar. In this study, plant height, the number of pods per plant, the number of seeds per pod, the number of seeds per plant, 1000-seed weight, seed yield, crude protein ratio, and crude protein yield were determined. PS1 line gave the highest values in terms of 1000-seed weight (288.87 g), seed yield (3336.3 kg/ha), and crude protein yield (619.1 kg/ha) based on two-year results. It was also determined that the PS1 line is a good cultivar candidate especially, in terms of seed yield.

Keywords: Genotypes, Plant height, 1000-seed weight, Crude protein ratio, Crude protein yield

1. Introduction

Field pea (*Pisum sativum* L.) is an annual plant of the legume family. The adaptation ability of field pea, which is a cool-season plant, is high. Field pea is a good intermediate crop, and it is utilised as a green fertilizer plant, is suitable for mixed cultivation. This plant is commonly grown for forage and seeds (Krga et al. 2019; Lakić et al. 2019; Halil & Uzun 2020). Field pea is resistant to cold, its seedlings can survive at -20 °C, and can be planted in many areas in winter (Shereena & Salim 2006). Pea seeds can be used as a valuable protein and energy source in feed rations instead of soybean which has the risk of GMO (Genetically Modified Organism). Cultivation of pea is easier compared to soybean; the oil content of pea seeds is lower than soybean seeds (Marohnić 2006; Rapčan et al. 2010; Krizmanić et al. 2020).

Field pea was included in the data of TUIK (Turkish Statistical Institute) for the first time in 2014 in Turkey. The cultivation areas of the field pea are increasing more and more. The cultivation areas of field pea are 24319 ha in 2020. As can be seen here, the cultivation area of the field pea increased approximately 6.5-fold in seven years. Despite this increase, the share of field pea in total forage crop cultivation areas is only 0.80% (Anonymous 2020). Field pea cultivars have been registered in Turkey since 2007; and according to official data, 30 cultivars have been registered until today (Anonymous 2021).

To increase animal production, it is necessary to increase the cultivation areas and production of forage crops. This can be accomplished largely by breeding productive and high-quality varieties. In this respect, new cultivars must be developed in field peas, and the field pea cultivation areas must be increased. It is necessary to develop productive and quality genotypes or to improve the insufficient sides of the existing cultivars with breeding studies (Ceyhan 2003).

Characteristics such as plant height, the number of seeds per plant, the number of pods per plant, the number of seeds per pod, and 1000-seed weight provide high seed yield in field pea as in the other plants. Kumar et al. (2013) submitted that pea grain yield might be increased by selecting genotypes that have a large number of pods per plant and a large number of seeds per pod. Researchers conducted studies on different plants and reported that the germination and seedling establishment of large seeds is better than small seeds; plants obtained from large seeds have high competition ability for plant-growth re-sources as soil water, soil nutrients, and light, field performance is better; seed yield could increase by 15%-20% with the use of quality seeds (Gan et al. 2006; Ambika et al. 2014). Tawaha & Turk (2004) reported that heavy seeds provided 12% more 100-seed

weight than light seeds. Smithcher & Weeden (2018) reported that the seed yield in large-seeded peas would be higher than small-seeded peas due to the higher harvest index however, they reported that the cost of seeds would also increase in such a case.

In this research, the main aim was to investigate the seed yield and quality properties of some pea lines obtained by hybridization method and to reveal a new variety candidate with superior characteristics.

2. Material and Methods

Field trials were performed in 2013-2014 and 2015-2016 at Bursa Uludag University, Faculty of Agriculture, Agricultural Research and Application Center in two years. The climatic data of the trial years are given in Table 1. As shown in Table 1, the total precipitation was 496.20 mm in the first year and 459.30 mm in the second year in the November-June period. Also, it is seen in Table 1 that the long term period total annual precipitation (558.30 mm) is more than in the period of these experiments. The average temperature in the plant development period was 12.50 °C in the first year, 13.13 °C in the second year, and 11.50 °C in the long term. In both years, it was determined that the average heats were more than the long term. The relative humidity values were found to be 71.17% and 72.64%, respectively. This value was reported as 71.00% as the average of long term (Anonymous 2016).

Table 1- Climate data of Bursa province in the years of research and the long term

	Precipitation (mm)			*Temperature (°C)*			*Relative Humidity (%)*		
Months	*Long Term*	*2013-14*	*2015-16*	*Long Term*	*2013-14*	*2015-16*	*Long Term*	*2013-14*	*2015-16*
November	74.40	60.80	26.40	12.2	11.80	12.74	74.30	75.40	78.05
December	101.80	38.60	3.00	7.60	4.90	5.60	73.60	66.80	76.60
January	92.50	30.80	122.20	5.30	8.98	5.20	75.00	70.42	80.70
February	78.40	20.40	80.70	6.30	8.55	11.10	73.10	73.66	76.00
March	70.30	42.40	75.60	8.30	10.65	11.20	72.20	69.57	71.00
April	59.20	112.00	22.80	12.8	14.51	16.40	69.50	71.09	65.30
May	50.40	96.80	67.30	17.50	18.32	18.30	68.80	71.73	71.20
June	31.30	94.40	36.40	22.20	22.29	24.50	61.30	70.66	62.30
Total/ Average	558.30	496.20	459.30	11.50	12.50	13.13	71.00	71.17	72.64

The soils of the trial area were generally clayey, had low organic matter content, and had no salinity, alkalinity problems.

The field pea genotypes were provided from different sources were crossed according to the semi-diallel hybridization method in 2007. The genotypes with large seeds, long pods, the high number of seeds in pod, and high seed yield per plant were selected in the later years. Seven advanced-generation field pea lines (PS1, PS2, PS3, PS4, PS5, PS6, PS7) were used in this study. The Golyazi cultivar was used as the control material in this study. Golyazi was a cultivar registered by Bursa Uludag University Faculty of Agriculture, Department of Field Crops, in 2007. This study was conducted to investigate the seed yield and quality characteristics of some field pea genotypes and to determine superior lines. The experiments were performed in a randomized block design with 3 replications.The study started in 2013-14, and the second year of the study was established in 2014-15. However, the experiment in the 2014-15 year was canceled because of winter damage. The trial was re-sown for winter in 2015-16, and the results of two years were used in the study. The seeds were sown manually at 100 seeds per square meter on 11.11.2013 and 06.11.2015.

The plot size was 6 m^2. The row spacing was 20 cm, and there were 6 rows in the plots. Fertilizer (30 kg/ha N) was applied after sowing. Weed control was done manually twice. Plants were sprayed twice with 10 days intervals against *Bruchus pisorum* at the flowering stage. The plant height, the number of pods per plant, the number of seeds per pod, and the number of seeds per plant was determined in 10 plants that were selected from each plot before the harvest. The harvest was performed using Hege 125 C Plot Combine (Hans-Ulrich Hege Maschinenbau, Hohebuch, Germany) on 10.06.2014 and 17.06.2016. After the harvest, the seeds were fumigated against *Bruchus pisorum* with Phostoxin tablets. After this process, the seeds were cleaned, and the seed yield and 1000-grain weights were determined. The nitrogen contents of the seeds were determined by the Micro Kjeldahl Method. By this method, the crude protein contents (Nx6.25) and the crude protein yields were calculated. The variance analysis was conducted using the JUMP 7.0 (SAS 1989-2002) package program. Comparisons between means were made using least significant differences (LSD) at 0.05 probability level.

3. Results and Discussion

The plant height, the number of pods per plant, the number of seeds per pod, the number of seeds per plant, 1000-seed weight, seed yield, crude protein ratio, and crude protein yield characteristics were examined in both years of this study.

3.1. Plant height

The results for the plant heights of the field pea genotypes are shown in Table 2. As seen in the table, the differences between plant heights were statistically significant at 1% probability level in genotype, year, and genotype x year interaction. As seen in the genotype averages, the highest plant height was obtained at the Golyazi cultivar with 145.12 cm and the lowest plant height value was at the PS7 with 78.95 cm (Table 2). Uzun et al. (2005) determined that the highest plant height was obtained at Golyazi cultivar with 158.6 cm in a study they conducted with different pea genotypes. The plants were taller in the first year (average 115.94 cm) than in the second year (average 78.77 cm) (Table 2). Since the total precipitation in the first year (496.20 mm) was higher than in the second year (459.30 mm) and the average temperature especially in the spring months in the first year was lower than in the second year plant height was higher (Table 1). In genotype x year interaction, the highest plant height was detected in the first year of the Golyazi cultivar (158.03 cm), and the lowest plant height was detected in the second year of the PS4 (64.20 cm), PS7 (64.00 cm), PS5 (60.93 cm), and PS2 (60.80 cm) lines (Table 2). In many studies conducted on peas, plant height values were reported to vary between 39.5 and 137.7 cm (Ibrahim et al. 2019; Krga et al. 2019; Prasad et al. 2019; Kadıoğlu et al. 2020; Krizmanić et al. 2020). Krizmanić et al. (2020) reported that the plant height was important as well as the number of seeds per pod, the number of pods per plant, and the 1000-seed weight in developing a productive and quality cultivar in field pea.

Table 2- Plant height and the number of pods per plant values of the pea genotypes

	Plant height (cm)			***The number of pods per plant***		
Genotypes	***2013-2014***	***2015-2016***	***Genotype average***	***2013-2014***	***2015-2016***	***Genotype average***
PS1	107.90 de	73.93 h	90.92 C	19.73 bc	11.60 fg	15.67 B
PS2	111.43 d	60.80 ı	86.12 D	21.67 ab	15.93 e	18.80 A
PS3	103.50 e	82.27 g	92.88 C	17.47 de	11.60 fg	14.53 BC
PS4	105.90 de	64.20 ı	85.05 D	20.23 bc	10.53 g	15.38 BC
PS5	126.60 b	60.93 ı	93.77 C	19.43 cd	10.40 g	14.92 BC
PS6	120.27 c	91.80 f	106.03 B	16.33 e	13.60 f	14.97 BC
PS7	93.90 f	64.00 ı	78.95 E	23.00 a	15.93 e	19.47 A
Golyazi	158.03 a	132.20 b	145.12 A	17.33 de	10.70 g	14.02 C
Year average	115.94 A	78.77 B		19.40 A	12.54 B	
LSD (%5)	G: 4.09	Y: 3.19	GxY: 5.79	G: 1.52	Y: 1.17	GxY: 2.15
P<0.05	G: **	Y: **	GxY: **	G: **	Y: **	GxY: **
CV (%)	3.56			8.08		

The difference between averages with the same letter is not significant (P<0.05) (LSD); * and **: significant at P= 0.05 and 0.01 (F-test) respectively; ns: not significant (F-test)

3.2. *Pods/Plant*

As seen in Table 2, the genotype, year, and genotype x year interaction were found to be statistically significant on the number of pods per plant at 1% probability level. According to two years average, the highest number of pods per plant was obtained at PS7 line with 19.47 and PS2 line with 18.80. The least number of pods per plant was determined at the Golyazi cultivar (14.02). According to the the differences between years, the highest number of pods per plant were taken in the first year with 19.40. In the trial, the number of pods per plant detected in the first year was higher than in the second year (Table 2). Especially the fact that the total precipitation in the flowering period in the first year (208.8 mm) was more than in the second year (90.1 mm) increased the number (Table 1). Harvey (1980) stated that peas are very sensitive to water during flowering and pod filling periods. As seen in genotype x year interaction in Table 2, the highest number of pods per plant was obtained from the PS7 line (23.00) in the first year of the study. The PS2 line (21.67) was also in the same statistical group with it. The number of pods per plant increased in the first year due to high precipitation especially in April and May (Table 1). Golyazi (10.70), PS4 (10.53), and PS5 (10.40) genotypes had the lowest number of pods per plant in the second year (Table 2). The number of pods per plant was varied between 2.6 and 30.4 in previous studies made with different pea genotypes in different years and locations (Singh et al. 2018; Ton et al. 2018; Jiang et al. 2020; Jiang et al. 2020; Kadıoglu et al. 2020). Lakić et al. (2019) reported that Kosev (2014) had explained that the number of pods per plant was important at increasing the yield. Georgieva et al. (2015) indicated that the effect of the number of pods per plant on the seed yield in peas was positive and significant. Furthermore, these researchers reported that field pea breeders should pay attention to the number of pods per plant in developing high-yield genotypes.

3.3. Seeds/Pod

The effects of genotypes and years were significant at 1% probability level for the number of seeds per pod (Table 3). According to the results of the study, the highest number of seeds per pod was obtained in the PS4 (4.97), PS7 (4.80), and PS1 (4.78) lines,

followed by PS3 (4.67) and PS6 (4.58) lines, which were in the same group. The lowest value was obtained in the Golyazi cultivar with 3.87 value. The number of seeds per pod obtained in the first year (4.71) was higher than in the second year (4.25) (Table 3). In the second year of the trial, the high-temperature values at the flowering time decreased the number of seeds per pod (Table 1). Although the number of seeds per pod is hereditary, it is affected by stress conditions (Egli & Bruening 2002). The number of seeds per pod decreases as stress continues (Jiang et al. 2020). The number of seeds per pod was varied between 3.73 and 5.40 in the genotype x year interaction (Table 3). Uzun et al. (2005) reported that the number of seeds per pod in pea ranged between 4.0 and 4.7 in a study conducted under Bursa ecological conditions. On the other hand, Prasad et al. (2019) found the number of seeds per pod between 2.1 and 5.2. These values are similar to the values in our study. Some researchers reported that the number of seeds per pod ranged between 5.27 and 7.5 (Ibrahim et al. 2019; Lakić et al. 2019; Kadıoglu et al.2020). Krizmanić et al. (2020) reported that the number of seeds per pod in field peas was one of the characteristics affecting the seed yield. Kumar et al. (2013) reported that when the number of seeds per pod was higher, it would increase the seed yield in peas.

Table 3- The number of seeds per pod and the number of seeds per plant values of the pea genotypes

	The number of seeds per pod			***The number of seeds per plant***		
Genotypes	***2013-2014***	***2015-2016***	***Genotype average***	***2013-2014***	***2015-2016***	***Genotype average***
PS1	4.87	4.70	4.78 A	68.40 a	52.87 cde	60.63 A
PS2	4.60	3.53	4.07 BC	54.67 bcd	36.87 ı	45.77 CD
PS3	4.63	4.70	4.67 AB	52.33 cde	38.60 hı	45.47 DE
PS4	5.40	4.53	4.97 A	59.27 b	38.20 ı	48.73 BCD
PS5	4.50	3.73	4.12 BC	56.10 bc	43.47 gh	49.78 B
PS6	4.67	4.50	4.58 AB	49.67 ef	34.80 ı	42.23 E
PS7	5.00	4.60	4.80 A	59.33 b	38.60 hı	48.97 BC
Golyazi	4.00	3.73	3.87 C	50.33 de	44.87 fg	47.60 BCD
Year average	4.71 A	4.25 B		56.26 A	41.03 B	
LSD (%5)	G: 0.62	Y: 0.25	GxY: 0.88	G: 3.47	Y: 2.86	GxY: 4.91
P<0.05	G: **	Y: **	GxY: ns	G: **	Y: **	GxY: **
CV (%)	11.83			6.04		

The difference between averages with the same letter is not significant (P<0.05) (LSD); * and **: significant at P= 0.05 and 0.01 (F-test) respectively; ns: not significant (F-test)

3.4. Seeds /Plant

The number of seeds per plant values are given in Table 3. As shown in Table 3, there were significant differences at 1% probability level between genotypes, years, and genotype x year interaction. In genotypes, the highest number of seeds per plant was in the PS1 line (60.63) due to high the number of seeds per pod and the number of pods per plant. The lowest number of seeds per plant was measured in the PS6 line (42.23). In the first year, the number of seeds per plant (56.25) was higher than in the second year (41.03). As seen in the genotype x year interaction, the highest number of seeds per plant was obtained in the first year of PS1 line and the lowest number of seeds per plant was obtained in the second year of PS4, PS2, and PS6 lines (Table 3). The number of seeds per plant varied from 24.5 to 102.8 at previous works (Uzun et al. 2005; Ton et al. 2018). Georgieva et al. (2015) explained that the number of seeds per plant was important in developing high-yield pea genotypes.

3.5. 1000-Seed weight

There were significant differences at 1% probability level between genotypes, and 5% probability level between years for the 1000-seed weight (Table 4). The highest 1000-seed weight was obtained from PS1 (288.87 g) and PS4 (282.51 g) lines. The lowest 1000-seed weight was determined at PS6 (180.82 g), PS7 (180.10 g) lines, and Golyazi (176.72 g) cultivar. It was found that the average 1000-seed weight of the genotypes in the first year (239.83 g) was higher than in the second year (226.86 g) (Table 4). 1000-seed weight decreased in the second year due to very low precipitation and slightly higher temperature during April and May (Table 1). In Bursa conditions, field peas usually begin to bloom and fill seeds in April-May. Smaller seeds are obtained under unfavorable environmental conditions (Singh et al. 2009). In a trial conducted by Gantner et al. (2008), it was reported that there was a negative relationship between pea yield with temperature in May and June. It was reported in previous studies conducted in peas that there is a positive relation between seed yield and 1000-seed weight, and 1000-seed weight should be considered as an important characteristic in achieving a high-yield cultivar (Kosev & Mikic 2012; Goa & Ashamo 2014; Georgieva et al. 2015). It was observed that 1000-seed weights varied between 175.25 and 296.33 g in the genotype x year interaction (Table 4). In previous studies conducted in peas, the 1000-seed weights of genotypes varied between 67.3 and 285.0 g (Tan et al. 2012; Ton et al. 2018; Lakić et al. 2019; Prasad et al. 2019; Krizmanić et al. 2020). The reason for this variation were different pea genotypes, sowing seasons, and climatic factors. Rapčan et al. (2010) reported that the location affected the 1000-seed weight at a significant level.

Table 4- 1000-seed weight and seed yield values of the pea genotypes

	1000-seed weight (g)			*Seed yield (kg/ha)*		
Genotypes	***2013-2014***	***2015-2016***	***Genotypes average***	***2013-2014***	***2015-2016***	***Genotypes average***
PS1	296.33	281.40	288.87 A	3529.3	3143.3	3336.3 A
PS2	286.57	262.42	274.49 B	2424.0	2194.3	2309.2 E
PS3	248.67	228.85	238.76 C	2525.0	2386.0	2455.5 D
PS4	290.43	274.58	282.51 A	3250.3	3053.3	3151.8 B
PS5	252.70	236.24	244.47 C	2587.0	2389.0	2488.0 CD
PS6	182.13	179.50	180.82 D	2166.7	2118.0	2142.3 F
PS7	183.57	176.62	180.10 D	2655.0	2562.7	2608.8 C
Golyazi	178.20	175.25	176.72 D	2066.3	2032.0	2049.2 F
Year average	239.83 A	226.86 B		2650.5 A	2484.8 B	
LSD (%5)	G: 7.47	Y: 8.13	GxY: 10.57	G:1.28	Y: 0.53	GxY: 1.82
P<0.05	G: **	Y: **	GxY: ns	G: **	Y: **	GxY: ns
CV (%)	4.24			2.72		

The difference between averages with the same letter is not significant (P<0.05) (LSD); * and **: significant at P= 0.05 and 0.01 (F-test) respectively; ns: not significant (F-test)

3.6. Seed yield

As shown in Table 4, the effect of only genotypes and years on the differences between seed yield was found to be statistically significant at 1% probability level. As seen in the genotype mean the highest seed yield was obtained in the PS1 line with 3336.3 kg/ha (Table 4). The seed yield of this line was higher than the other genotypes due to the high number of seeds per plant and 1000-seed weight. Some researchers reported that there is a positive relation between seed yield with the number of seeds per plant, and 1000-seed weight in field pea (Kosev & Mikic 2012; Anwar et al. 2014; Goa & Ashamo 2014). In this study, the lowest seed yield was found at the Golyazi cultivar (2049.2 kg/ha) and the PS6 line (2142.3 kg/ha) (Table 4). As understood from the table, the seed yield of the PS1 line was found to be 63% higher than the Golyazi cultivar, which was used as the control. The mean seed yield of the first year (2650.5 kg/ha) was 7% higher than the second year (2484.8 kg/ha) (Table 4). The values of all characteristics that were examined, including seed yield, were found to be higher in the first year. The high rainfall in April and May (112.0 mm and 96.80 mm, respectively), which are the flowering and seed-filling times, and the low temperatures in April (14.51 °C) increased the seed yield in the first year (Table 1). Rapčan et al. (2010) reported that a sufficient amount of rainfall and air temperature particularly during flowering is important in obtaining the high seed yield in pea. According to several studies, it has been observed that pea are sensitive to high temperature and low precipitation, especially in the generative period. (Uzun et al. 2005; Gullap et al. 2017). The average daily air temperature is 15-18 °C for the flowering of peas. Temperatures above 26 °C immediately after flowering decrease seed yield in pea because of the flower falling (Popović et al. 2002; Rapčan et al. 2010). Plants are vulnerable to heat stress in the pre-pollination and post-pollination stage. Heat stress causes yield loss by limiting seed filling time or seed filling rate (Uzun et al. 2005; Hedhly 2011; Kaushal et al. 2016). In our study, according to the State Meteorology Department, in the second year, the maximum temperatures recorded in February, March, April, and May were 25.4, 25.7, 30.5, and 32.4 °C, respectively. Whereas, in the first year, the maximum temperatures were 14.39, 16.05, 20.6, and 23.93 °C, respectively. As is seen, the maximum temperatures of the second year were higher than the maximum temperatures of the first year (Anonymous 2016). Therefore, results of research were shown that the seed yield in the first year was more greater compared to the second year. Also, a pea is sensitive to water. Water sensitivity increases especially during flowering and pod settings. Inadequate water in the flowering period affects negatively fertilization causing flower losses (Harvey 1980). In our study, although the total precipitation in the flowering and pod setting periods was 208.80 mm in the first year, the second year was only 90.10 mm (Table 1). Uzun et al. (2005) reported that drought in the flowering and pod-filling period reduced seed yield of field pea. The mean seed yields were varied between 2032.0 and 3529.3 kg/ha in the present study. Previous studies in different years and locations with different pea genotypes have shown that seed yield varied from 1040.0-5130.0 kg/ha (Gullap et al. 2017; Ton et al. 2018; Ibrahim et al. 2019; Lakić et al. 2019; Kadıoglu et al. 2020; Krizmanić et al. 2020).

3.7. Crude protein ratio

In terms of crude protein ratio, only the differences between genotypes were significant at the 1% probability level (Table 5). The highest crude protein ratio was obtained from the PS6 line with 21.12%, and Golyazi (20.15%), PS7 (20.12%), PS3 (19.43%), and PS5 (19.42%) genotypes were also in the same statistical group (Table 5). Crude protein ratios of these genotypes were high, due to low 1000-seed weight. The crude protein ratio of Golyazi cultivar varied from 11.6 to 22.8% in previous experiments conducted in the same (Uzun et al. 2012) and different (Cacan et al. 2018) locations. The lowest crude protein ratio (17.82%) was observed in the PS4 line. In our study, the crude protein ratio varied between %18.47-21.13% (Table 5). In different

studies conducted on peas, this value was reported to vary between %16.4-27.3% (Uzun et al. 2012; Gullap et al. 2017; Księżak et al. 2018; Singh et al. 2018; Ada et al. 2019; Goswami & Shukla 2019).

Table 5- Crude protein ratio and crude protein yield values of the pea genotypes

	Crude protein ratio (%)			*Crude protein yield (kg/ha)*		
Genotypes	***2013-2014***	***2015-2016***	***Genotype average***	***2013-2014***	***2015-2016***	***Genotype average***
PS1	18.47	18.67	18.57 BC	651.6	586.6	619.1 A
PS2	18.87	19.23	19.05 BC	458.0	422.1	440.0 DE
PS3	19.20	19.67	19.43 ABC	485.4	469.6	477.5 CD
PS4	19.30	16.33	17.82 C	627.4	497.4	562.4 AB
PS5	19.87	18.97	19.42 ABC	514.0	453.1	483.6 CD
PS6	21.10	21.13	21.12 A	457.1	447.6	452.4 DE
PS7	20.57	19.68	20.12 AB	545.4	504.3	524.8 BC
Golyazi	20.10	20.20	20.15 AB	415.4	410.4	412.9 E
Year average	19.68	19.24		519.3 A	473.9 B	
LSD (%5)	G: 1.75	Y: 1.00	GxY: 2.48	G: 0.57	Y: 0.31	GxY: 0.81
P<0.05	G: *	Y: ns	GxY: ns	G: **	Y: *	GxY: ns
CV (%)	7.61			9.81		

The difference between averages with the same letter is not significant (P<0.05) (LSD); * and **: significant at P= 0.05 and 0.01 (F-test) respectively; ns: not significant (F-test)

3.8. Crude protein yield

The crude protein yield differences were found to be significant at 1% probability level in genotypes, and at 5% probability level in years; and were found to be insignificant in genotype x year interaction. The highest average crude protein yield was obtained from the PS1 line with 619.1 kg/ha. The PS4 line (562.4 kg/ha) was also in the same group with the PS1 line. The Golyazi cultivar had the lowest crude protein yield compared to the other genotypes. Previous studies have shown that the crude protein yield of the Golyazi cultivar varied from 370.0 kg/ha to 853.0 kg/ha (Uzun et al. 2005; Cacan et al. 2018). As seen in Table 5, the average crude protein yield in the first year (519.3 kg/ha) was higher than the average crude protein yield in the second year (473.9 kg/ha) due to higher seed yield and crude protein ratio in the first year. It was reported in various studies conducted on peas that crude protein yield values ranged between 119.0-1049.0 kg/ha (Rapčan et al. 2010; Uzun et al. 2012; Cacan et al. 2018).

4. Conclusions

This study aimed to determine the seed yield and quality characteristics of some field pea genotypes at Bursa ecological conditions and to propose a new field pea cultivar candidate. According to the data obtained in this study, it was determined that the PS1 line surpassed the control cultivar and other lines in many characteristics. Based on seed yield and quality values at two years of Bursa ecological conditions, PS1 line can be considered for a new cultivar candidate.

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