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Stabilities of Some Local Pea Lines

Reyhan KARAYEL[a]*, Hatice BOZOĞLU[b]

[a] *The Black Sea Agriculture Research Institute, Samsun, TURKEY*

[b] *University of Ondokuzmayıs, Faculty of Agriculture, Samsun, TURKEY*

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Corresponding Author: Reyhan KARAYEL, E-mail: reyhan.karayel@tarimorman.gov.tr

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ABSTRACT

This study was conducted to determine the stabilities and adaptation classes of edible pea lines, which will be cultivated in mild climate regions. Twenty local pea lines selected in previous breeding studies and 6 control varieties were used. The seeds of pea lines were sowed in 4 different locations in 2 sowing times. The experiment was conducted according to the Augmented design. Adaptation classes and stabilities of pea lines and varieties were determined based on fresh pod yield, fresh seed yield and dry seed yield. The mean of fresh pod yield was found as 1185.7 kg da^{-1}. Stable variety was not determined in terms of fresh pod yield among control varieties, which was conducted in the conclusion of evaluation as determining regression coefficient and average reliability. The average of varieties' fresh seed yield was 693.8 kg da^{-1}, Klein variety showed medium adaptation for all regions. It was found that 3 lines (B_{15}, B_{33}, and B_{36}) among used ones were placed at the same statistically group with this variety. The average of dry seed yield was 267.1 kg da^{-1} in the experiment, and Klein, Further, Green Pearl, and Lancet varieties were identified as stable varieties in the conclusion of stability analysis. B_6, B_{13}, B_{14}, B_{15}, B_{16}, B_{17}, B_{18}, B_{32}, B_{40} and B_{42} lines that involved in the same statistically group with these varieties identified were as stable. In the conclusion of the overall evaluation of the experiment, it was found that B_6 and B_{32} lines could be candidates for variety.

Keywords: Pea, Stability, Yield, Adaptation classes

1. Introduction

Pea is one of the most commonly used edible grain legumes. Thus, studies have been extensively carried out to investigate several aspects of pea cultivars in all over the world. Fresh pods and seeds of peas are used as fresh, frozen or canned vegetable and dry seeds or whole plant is used as forage (Akçin 1988). In addition, recently in the USA and also in many countries, the pea is used as modernist bakery products such as functional food, protein concentrates (55-60% protein) and isolates (85% protein), and as protein, folate and mineral enhancer in bread, pasta, cereals for breakfast, biscuits, crackers, energy bars, pressed cookies and processed meat products (URL-1). The largest cultivation of pea in the world takes place in Canada, where has the largest cultivation area in the world. In Canada, the pea is used for making bread because of due to the fiber-rich ingredient. The protein extracted from pea is used consumed as alternative source of protein by for the people who have soybean allergy as alternative source of protein and to enrichment of the animal rations. The cellulose of pea is used for fermented sausage and breakfast cereals and confectionery because of the swelling and water holding characteristics. In addition, pea starch is used in thickener, adhesive and carbon paper productions (Ratnayake et al. 2001). According to FAO 2018 statistics, dry pea cultivation area was 7.8 million ha, its yield was 171.8 kg da^{-1} and fresh pea cultivation area was 2.7 million ha, the yield was 773.6 kg da^{-1} in the world in 2018. The agriculture of pea is not widespread like chickpea, lentil and bean in Turkey. In Turkey, cultivation area of dry pea is 907 ha, production amount is 2603 tons, average yield is 287.0 kg da^{-1}; vegetable pea cultivation area is 10 917 ha, production amount is 107 344 tons, the average yield is 983.2 kg da^{-1} for fresh consumption. According to these statistics, Turkey takes the last ranks among countries, which cultivate pea. However, Anatolia, one of the origin centers of the pea, has suitable ecological conditions for pea cultivation. Pea agriculture becomes intense in the areas where are food industry regions in Turkey and its agriculture is maintained with Northern European countries varieties. In addition, local pea varieties were cultivated in the small family farms located in coastal regions with mild climate. Development of new varieties and determining the characteristics of local varieties are important to expand the pea cultivation. The environmental characteristics of a region and genotypic factors have significant impacts on yield performances of pea genotypes. Therefore, long-term studies should be conducted in several regions with different environmental characteristics. In these studies, both the differences between genotypes and genotype x environment interactions which come up because of showing different reactions of genotypes in different environments are analyzed.

The main objectives of plant breeding studies are developing highly productive varieties and making the new varieties available for producers. Therefore, studies primarily focused to develop advanced pea lines and determine the promising characteristics. The data obtained in these studies reveal the information on performances of varieties under different environmental conditions, and the findings are evaluated using specific statistical methods.

Stability analyses are applied to choose genotype when genotype x environment interactions indicated by variance analysis are significant. Stability is defined as to estimates of a change in environmental conditions, potential effects on genotypes (Kafa and Kırtok 1991). Becker (1981) defined biological stability as varieties showing a stable yield in different environments and as to agricultural stability as varieties in a certain environment has the specified level of efficiency in that environment. If genotype x environmental interactions are significant, the breeder should determine genotypes that do not show much variability in their productivity under changing environmental conditions, that is to say stable genotypes (Bozoğlu and Gülümser 2000).

Expansion of pea cultivation in our country as in developed countries of the world will make a significant contribution to food processing industry and agriculture. The most important duty of a breeder or an agronomist is to support this projection by ensuring the sustainability of local materials and developing new varieties suitable for the different regions of the country.

The pea is an important legume that can be used in crop rotation and sown as a winter crop in mild climate regions. Therefore, this study aimed to determine the stabilities of edible variety pea candidates, which have been determined as lines by choosing among local pea populations.

2. Material and Methods

The study was conducted in 8 different environments (Amasya, Samsun-Atakum, Samsun-Gelemen and, Tokat in 2 different sowing times winter and early spring) during 2015 and 2016. Some of the climatic data belonged to the environments where the experiments were carried out were presented in Figure 1 and 2. The data indicated that climates of Amasya and Tokat, Gelemen and Atakum are similar.

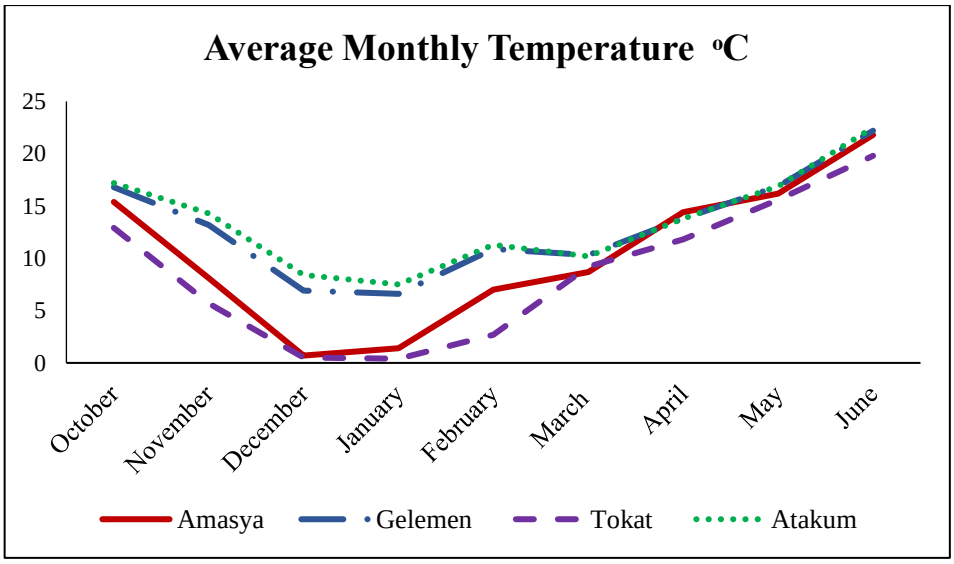

Figure 1- 2015-2016 temperature values in the locations where experiments are carried out

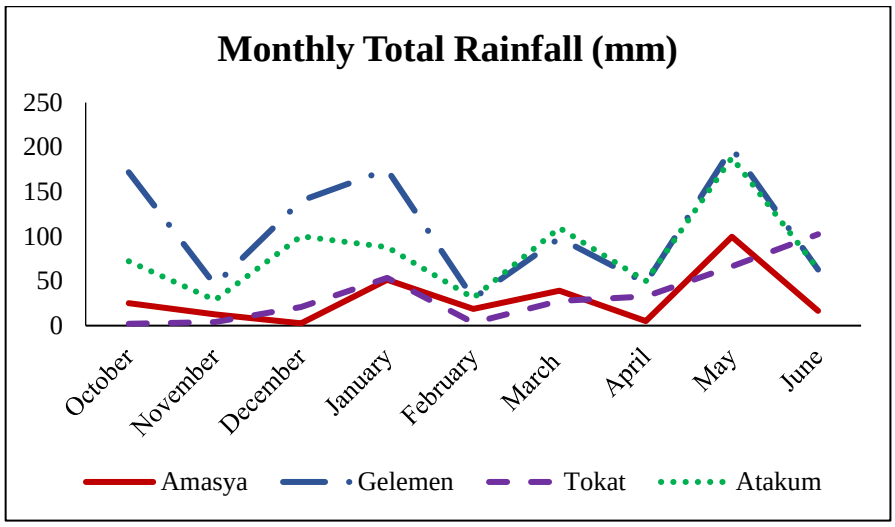

Figure 2- 2015-2016 rainfall values in the locations where experiments are carried out

Some differences were found out for the environments' soil characteristics. When Table 1 is analyzed, it is understood that insignificant variations were seen for soil type, pH and salinity, whereas there was no variation for potassium among regions. Significant variations were seen for lime and organic substance at other characteristics.

Table 1- Analysis results of soil properties of trial areas

Properties	*Amasya*	*Samsun-Gelemen*	*Samsun-Atakum*	*Tokat*
Saturation %	Clayey loam	Clayey loam	Clayey	Clayey loam
pH	Neutral	Slightly alkaline	Neutral	Slightly alkaline
Lime ($CaCO_3$)	High limy	Very low limy	Limy	Middle limy
% Total Salt %	Unsalted	Unsalted	Slightly salty	Unsalted
Phosphorus (P_2O_5 kg da^{-1})	Very high	Very high	Low	Very low
Potassium (K_2O kg da^{-1})	High	High	High	High
Organic matter %	Low	Low	Low	Very low

In the study 20 lines selected fresh and dry seed purpose fully with selection breeding among local pea materials (Karayel and Bozoğlu 2008) and 6 control varieties (Green Pearl, Sprinter, Further, Vilmoren, Lancet, and Klein) were used.

The experiments were carried out according to the Augmented Design in which the control varieties were placed in 3 blocks, and the lines were randomly placed in 3 blocks. The seeds of control varieties were sown at 60 cm row spacings on 4 rows with 4 m length, while the lines were sown on 2 rows at the same row spacings. The sowing dates for winter and early spring were given in Table 2. The experiments were carried out under rainfed conditions. Weed control was performed by hoeing when necessary. The pea was harvested as fresh and dry to determine the candidate varieties. The fresh and dry harvest dates were given in Table 2. Statistical analysis was carried out using SPSS software. Stability analyses were used to control varieties with regression model as Eberhart-Russell (1966) suggested and adaptation classes were applied as Arshad (1990) suggested. Varieties that average was higher than general average, regression coefficient (b) was equal to 1, regression deviation (S^2 b) variance was 0 or near 0 were defined as stable. Genotypes adaptation classes were defined as using experiments' general average ($\bar{x}$), regression coefficient (bi) and confidence limits (G.S= $\bar{x} \pm t \, . \, S \, \bar{x}$) determined for it (Bozoğlu & Gülümser 2000). These parameters were determined for control varieties, because Augmented Design was used for our experiment and at this design, only the control varieties values' variance analyses were done. The adaptation classes of control varieties and the lines those were placed at the same static group were decided regarding 5 % probability with LSD test grouping in the conclusion of variance analyses.

Table 2- Sowing dates and harvest date ranges of experiments

Location	*Winter sown date*	*Early spring sown date*	*Fresh harvest dates*	*Dry harvest dates*
Samsun-Gelemen	04.11.2015	04.03.2016	18.05.- 01.06.2016	20.06- 30.06.2016
Samsun-Atakum	20.11.2015	03.03.2016	20.05-18.06.2016	13.06-25.06.2016
Amasya	28.10.2015	09.03.2016	20.05-17.06.2016	16.06-24.06.2016
Tokat	05.11.2015	02.03.2016	15.04- 27.05.2016	20.05- 17.06.2016

3. Results and Discussion

Pea is a cool season legume plant. Total temperature demand of peas is 1600-2800 °C for full maturity; generally, it is sowed in autumn in mild climate regions, though it is sowed in early spring in regions where the winter is spent hard. Experiments were established in the same environment in two different planting times (winter and early spring) to create a different environment. Experiments were carried out at 8 environments with 6 control varieties and 30 lines. Their yield values and averages belonging to parameters required for stability and statistical grouping were given at Table 3.

Table 3- Stability parameters of yield values of pea genotypes grown in different environments

Genotypes	FPY (kg da^{-1})	RC (bi)	DR (S^2d)	FSY (kg da^{-1})	RC (bi)	DR (S^2d)	DSY (kg da^{-1})	RC (bi)	DR (S^2d)
G. Pearl	1155.8 de	0.52	156012	682.2 cd	0.40	62292	281.3 abc	1.10	2266
Sprinter	1359.5 cd	1.95	219404	695.8 cd	1.31	84656	313.8 a	1.7	2903
Further	1017.9 d-h	0.78	126933	570.7 e-h	0.42	28322	263.9 b-e	1.01	4281
Vilmoren	986.4 dfg	0.42	68844	744.4 c	1.11	28867	205.7 g-j	0.1	3293
Lancet	1503.5 bc	1.39	347737	788.6 bc	1.78	115909	306.8 ab	1.12	5068
Klein	1091.3 df	0.94	43318.3	681.0 cde	0.97	892.4	231.3 c-j	0.97	7387
Mean	1185.7	1		693.8	1		267.1	1	
CL	X±83.44	X±0.24		X±77.1	X±0.28		X±44.56	X±0.54	
B1	759.4 ij			410.3 ij			206.9 h-k		
B3	756.7 ij			471.4 hi			219.4 f-j		
B6	1734.3 a			975.9 a			320.9 a		
B10	811.5 hij			490.1g hi			243.4 jk		
B11	751.7 ij			484.6 ghi			271.7 f-j		
B13	782.8h ij			398.2 ij			170.4 jk		
B14	703.9 j			314.0 j			209.1 d-j		
B15	1057.0 df			535.5 fgh			295.5 a-d		
B16	769.0 hij			408.0 ij			223.1 e-j		
B17	642.1 j			376.6 ij			287.1 c-h		
B18	695.0 j			405.4 ij			248.9 b-f		
B19	784.0 hij			410.1 ij			290.0 hij		
B32	1587.6 ab			868.0 ab			298.9 c-i		
B33	909.9 e-i			548.5 fgh			211.2 d-jj		
B34	787.9 hij			595.3 d-g			241.7 ij		
B35	731.7 j			401.4 ij			204.7 jk		
B36	945.3 e-i			551.0 fgh			232.3 h-k		
B40	688.8 j			558.1 fgh			311.6 a		
B41	756.8 ij			331.5 j			241.5 h-k		
B42	969.6 d-i			533.4 fgh			247.7 d-j		
LSD	205.1			116.4			49.8		

RC: Regression Coefficient (bi); DR: Deviation from Regression (S^2d); CL: Confidence Limits; FPY: Fresh Pod Yield; FSY: Fresh Seed Yield; DSY: Dry Seed Yield, LSD: Least Significant Difference

3.1. Fresh pod yield

Pea is consumed as fresh seed, and sold with pods at local public markets in Turkey. Thus, the freshness of seeds after the harvest can conserve for a while. Therefore, the pod yield should also be determined. Since no graining is needed, the unit price is low. In our study, the average of fresh pod yield was 1185.7 kg da^{-1}, and as control varieties Sprinter and Lancet had higher values than the overall average. Regression coefficient of Lancet variety was nearer to 1. Sprinter and Lancet showed well adaptation to good environmental conditions as it can be seen from the stability graphic (Figure 3) given for fresh pod yield. The assessment conducted with mean confidence intervals and regression coefficients obtained using the fresh pod yield among the control varieties indicated no stable variety. Murtaza et al. (2007) stated fresh pod yield for pea was 276.7 - 525.5 kg da^{-1} (318.9 kg da^{-1} in control) for salicylic acid applications on pea seeds and leaves in Pakistan; Alam et al. (2010) stated it was 584.0 – 1144.0

kg da^{-1} for different fertilizer grade applications on pea in Bangladesh; Rasaei et al. (2012) stated it was 430.0- 910.0 kg da^{-1} for different irrigation dates and frequencies on pea in Iran; Gopinath and Mina (2011) stated it was 220.0- 724.0 kg da^{-1} for organic fertilizer applications on pea in India. According to the conclusion of multiple range test (LSD), it was found that B_6 (1734.3 kg da^{-1}) and B_{32} (909.9 kg da^{-1}) were placed at the same group with Lancet variety which showed well adaptation to good environmental conditions among 20 lines that was used (Table 2).

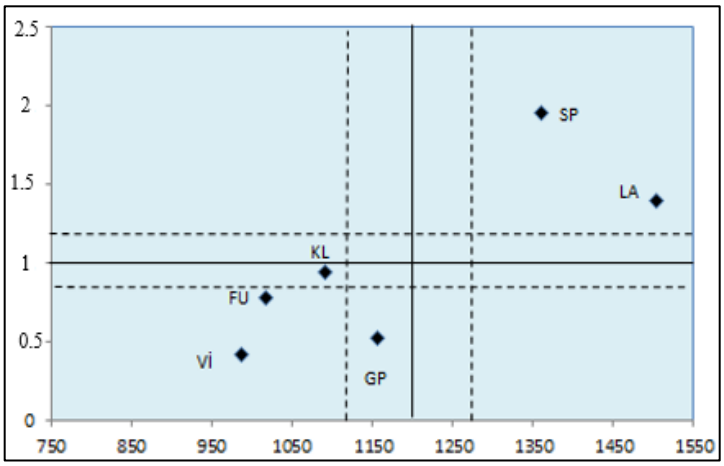

Figure 3- Stability graph of fresh pod yield of pea varieties

3.2. Fresh seed yield

Fresh pea seed is consumed both as fresh to cook directly and mostly canned in Turkey. The fresh seed yield was significantly different between genotypes and changed depending on the harvest dates. The seeds were lighter in early harvest, whereas peel pod was thinner and seed weight was heavier in the late harvest due to carbohydrate accumulation. Kalapchieva and Pevicharova (2009) reported that fresh seed yield ranged between 253.2 and 618.0 kg da^{-1} in 2000 and 2004 for Marsi variety, which is a new variety in Bulgaria. The difference in yield values can be attributed to the differences in the genotypes used and the growing environments. In our study, mean fresh seed yield for control varieties was 693.8 kg da^{-1}. The mean yield of Sprinter, Vilmoren and Lancet varieties was higher than the overall average yield value (Table 2). B_6 line gave the highest fresh seed yield as 975.9 kg da^{-1} among lines. It was determined that control varieties were different from that line statistically. B_{32} line came after B_6 with 868.0 kg da^{-1} fresh seed yield. That line placed at the same statistic group with Lancet which showed well adaptation to good environmental conditions (Figure 4). Calculated confidence limit for the average of experiment's fresh seed yield changed between 616.7-770.9 kg da^{-1}. Klein and Vilmoren showed medium adaptation to all environments, it was found that they were the most stable varieties namely. Only one line (B_{34}) placed at the same group with those varieties statistically.

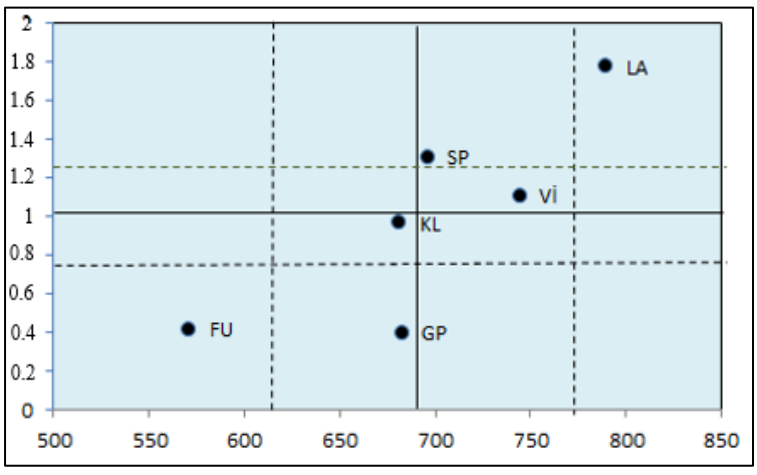

Figure 4- Stability graph of fresh seed yield of pea varieties

It was found that Klein and Vilmoren showed medium adaptation to all environments, namely stable, Lancet showed well adaptation to good environmental conditions, Green Pearl showed medium adaptation to bad environmental conditions. Among the lines only B_{34} line placed at the same statistic group with these varieties, and it was determined as stable line in terms of fresh seed.

3.3. Dry Seed Yield

High protein content of edible legumes consumed as dry seed come into prominence. Dry seed yield is an important trait even if pea is not consumed as dry seed. Various dry seed yields have been reported in studies conducted different ecological regions of Turkey. Öz & Karasu (2010) reported dry seed yield between 96.8 and 149.0 kg da^{-1} under ecological conditions of Bursa province, and the dry seed yield in İzmir ecology was between 143.0 and 349.0 kg da^{-1} (Alan & Geren 2012). The dry seed yield under Ankara ecology ranged from 190.9 to 276.4 kg da^{-1} (Kara & Ünver 1999). Dry seed yield recorded in this study was 267.1 kg da^{-1}, which was higher than the dry seed yields reported in literature and mean value in Turkey. Bozoğlu et al. (2007) found that dry seed yield was 212.4 kg da^{-1} averagely for winter sowing and 164.6 kg da^{-1} for in summer sowing in their study with 15 genotypes under Samsun's conditions. It was stated that Vilmoren and Sprinter placed at the first lines particularly in winter sowings. Except Vilmoren and Sprinter, all other control varieties were between confidence limit (222.54-311.66 kg da^{-1}) that is determined $P<0.05$ probability. This limit changed between 0.46-1.54 for regression coefficient. In this case Klein, Further, G. Pearl, and Lancet showed medium adaptation to all environments in terms of dry seed yield, namely they became stable varieties (Figure 5). It was found that all lines placed at the same group with stable varieties regarding applied LSD grouping.

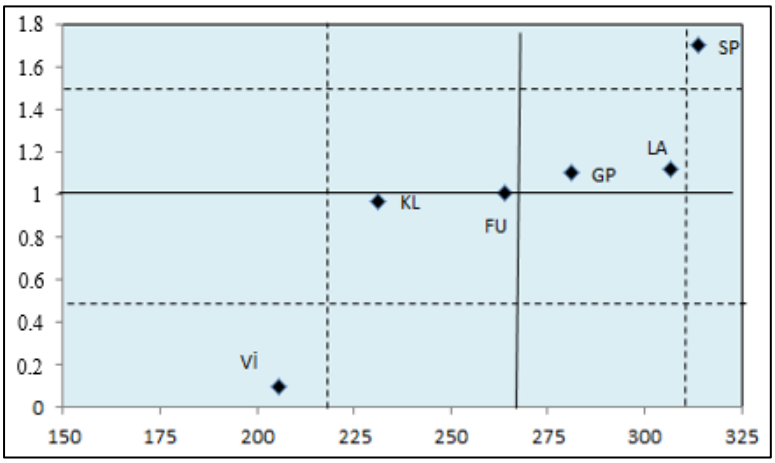

Figure 5- Stability graph of dry seed yield of pea varieties

4. Conclusions

The problem of coronavirus disease (COVID-19) that whole world threaten indicated the importance of health to all human being, and emphasized the necessity of living compatible with nature and sustainable use of natural sources. Seed is the most important and non-replaceable input of agricultural production. Domestic seeds, exist for hundreds of thousands of years in a geography are the most valuable sources of modern agriculture. Turkey is one of the germplasm centers of the pea. The aim of this study was determine the pea variety candidates by identifying the adaptation classes and the stabilities of local pea lines determined by the long-term field studies based on the yield characteristics. The experimental was carried out according to the Augmented design with 6 control varieties and 20 lines. Stability analyses were applied for control varieties. The data obtained in stability analysis were interpreted using LSD.

Although adaptation classes were same based on the regression coefficient the deviation, and the confidence limits for dry seed yield, it was found that multiple range test groups were different. It showed that lines and control varieties should be repeated as equal numbers, and a common stability parameter should be determined to make stabilities come up more precise.

The experiments carried out in 8 different environments indicated that the mean fresh pod yield, fresh seed yield and dry seed yield were 1188.7, 693.8 and 267.1 kg da^{-1}, respectively. Fresh pod and seed yield of B_6 and B_{32} lines were higher than those obtained from control pea varieties. The dry seed yield of B_6, B_{15}, B_{32} and B_{40} lines exceeded the overall average dry seed yield. The stability analysis revealed that B_6 and B_{32} lines are stable in terms of fresh pod and seed yield. Klein, Further, Green Pearl and Lancet varieties and B_6, B_{13}, B_{14}, B_{15}, B_{16}, B_{17}, B_{18}, B_{32}, B_{40} and B_{42} lines are stable for dry seed yield. Although some licensed varieties are available for the production of fresh seed in Turkey, no licensed local varieties are available for the production dry seed. The results of this study concluded that B_6 and B_{32} lines could be considered as the variety candidates in terms of yield parameters obtained.

Acknowledgements

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