MORPHOLOGICAL CHARACTERISTICS AND SEED YIELD OF EAST ANATOLIAN LOCAL FORAGE PEA (*Pisum sativum* ssp. *arvense* L.) ECOTYPES

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ABSTRACT

Local forage pea ecotypes, (*Pisum sativum* sp. *arvense* L.) have been cultivated by farmers in the Northern part of the Eastern Anatolia region of Turkey for years and there has not been any breeding regarding these materials up to now. Thus, the material shows great variation with respect to morphological and agronomical characters compared to commercial forage pea cultivars. The objective of this study was to evaluate yield and some traits of promised local pea ecotypes which were selected previous year's screening study material collected from 61 different locations in the northern part of the Eastern Anatolia in 2007. All seed materials were sown with randomized complete blocks design with three replicates in Atatürk University Faculty of Agriculture Experimental Station in 2009 and 2010. There were considerable variations with respect to investigated characters among the ecotypes and also significant interactions over the years. According to two years results, investigated properties were varied from 83.5 to 126.5 cm for plant height, 102 to 116.5 days for days to harvest, 10.4 to 15.5 for pod number per plant, 3.5 to 5.6 for seed number per pod, 3.0 to 4.4 for lodging score, 67.3 to 227.4 g for 1000 kernel weight, 3.37 to 4.57 t ha^{-1} for straw yield, 1.50 to 2.21 t ha^{-1} for seed yield and 27.5 to 35.9 % for harvest index. As a result, Avcilar and Ortakent ecotypes were considered to be tested in location experiment for new variety development because these ecotypes performed more stable results across the years and higher yield performance.

Key Words: Forage pea, ecotypes, seed yield, plant traits

INTRODUCTION

Pea is an important annual legume grown and consumed extensively both human and animal feed. Forage peas widely grown for hay, pasturage or silage production either alone or mixed with cereals (McKenzie and Spooner, 1999). Both seeds and forages of pea are rich in protein and mineral content (Acikgoz et al., 1985). Due to containing high quality and quantity protein, pea grains use as a grain feed in local animal breeders in Turkey and its surroundings. Pea is also used as alternative protein source in animal feed industry in Europe (Bourdillion, 1999; Acikgoz, 2001). On the other hand, forage pea is a very suitable crop in annual crop rotation because it provides biological nitrogen for plants sown after them. A local population of forage pea, locally called as 'kulur' has been cultivated in the provinces of Ardahan, Bayburt, Erzurum and Kars, which are located in the northern part of Eastern Anatolia for long years.

Seed production is a significant trait for pea crops because it is an important protein source. Especially in Europe, it is considered protein-rich feedstuff in animal feeding to replace soybean because Europe has long been deficient in protein-rich feedstuff and has relied heavily on soybean meal and other oil seed meals. Hence, the European Union encouraged the use and development of local pea crops to improve self-sufficiency in protein-rich feed stuff, to limit dependency on imports (Santalla et al., 2001).

Although forage pea landraces have locally been cultivated for a long time, there has not any breeding study performed on the material so far in the region. Landraces made up genetic types (Knauft and Gardner, 1998) but they have lower yield performance and uneven crop compared to improved varieties. Landraces have a great potential for new variety development by selection (Karayel and Bozoglu, 2008). Considerable breeding efforts have been made with pea to develop high-yielding variety in the last decades using local or introduced material in Turkey (Acikgoz and Uzun, 1997; Bilgili and Acikgoz, 1999; Tekeli and Ates, 2003; Timuragaoglu et al., 2004; Sayar et al., 2009). But there has not been a recorded variety development study on pea landraces of northern part of the Eastern Anatolia region up to now.

Breeding varieties for high yield has been the main objective and standing ability to overcome harvesting difficulties is the main priority in seed production in pea. Lodging is a serious problem for sole grown pea due to decreasing photosynthetic activity and increasing pathogenic infection. The severity of lodging hazard in pea changes depending on genotypes (Biarnes-Dumoulin et al., 1996; Uzun et al., 2005).

Unimproved varieties, local populations, shows high degree of genetic diversity, thus, great differences occur with respect to morphological traits, time to maturity, pod size and type, seed attributes, and yield (Santalla et al., 2001). These properties can be improved by selection so that yield performance can be increased.

Short growing season restrict productivity and diversity in the plant production, therefore animal production has a significant role in the region's agriculture. Thus, pea production, especially seed as a protein-rich feed stuff, is important for the region with respect to both feed stuff production and rotation crop in field crop production. On the other hand, local ecotypes are well adapted to local environment, and have a huge genetic diversity. The aim of this study was to evaluate morphological and agronomical traits of local pea ecotypes collected from the northern part of the Eastern Anatolia Region of Turkey.

MATERIALS AND METHODS

The experiment was conducted at the experimental station of Agricultural Faculty of Ataturk University, Erzurum, which is located at an altitude of 1850 m and between 39^0 59' N and 41^0 61'E. Field observations were done during the growing season of 2009 and 2010. Climatic properties of Erzurum are characterized by long and extremely cold winter and cool, short and arid summer. The distribution of precipitation is uneven, with majority of precipitation received from autumn to spring. Seed ripening extend to middle of the summer, hence, irrigation necessary to enhance proficient seed yield in pea production. Total precipitation and annual mean temperature in the experimental years and long term average are given in Table 1. Long term period annual mean temperature was 5.4 ^{0}C and annual total precipitation was 410,2 mm. In the experimental years, total annual precipitation mean annual temperature was 437,8 mm and 5.8 ^{o}C in 2009 and 475.9 mm and 7.9 ^{o}C in 2010, respectively (Anonymous, 2010). Insufficient precipitation occurred after June in both of the experimental years. Severe hail cases occurred on June 18, 2010 which caused pod and flower senescence in the plants. Soil texture of the study area is clay-loam with pH of 7.82. Organic matter content of experimental area soils is 1.90% and corresponding available potassium and Olsen phosphorus content were 1980 kg K_2O ha^{-1} and 88.0 kg P_2O_5 ha^{-1}, respectively.

A total of 22 pea ecotypes selected from previous year's screening study conducted on pea (*Pisum sativum* ssp *arvense* L.) ecotypes were used in the experiment. They were collected from 61 different locations in four provinces (Ardahan, Bayburt, Erzurum and Kars) in the northern part of Eastern Anatolia. The ecotypes having higher yield performance than population average were selected for this experiment. The ecotypes were named based on the collecting site names and their locations shown on Figure 1. Some morphological characteristics of the pea ecotypes used in the experiment were summarized in Table 2.

Table 1. Temperature and precipitation values of the experimental years and long term period

Mounths	Average temperature (°C)			Total rainfall (mm)		
	2009	2010	Long term	2009	2010	Long term
January	-12.1	-4.3	-9.7	2.3	52.2	19.8
February	-3.1	-1.8	-8.6	18.8	14.8	24.8
March	-0.7	3.1	-2.8	51.1	82.2	31.0
April	4.3	5.6	5.4	42.7	54.2	58.4
May	10.0	10.4	10.5	43.2	63.6	70.0
June	14.7	15.9	14.9	76.2	50.5	41.6
July	17.2	19.5	19.3	29.2	55.5	26.2
August	17.1	20.3	19.4	22.8	9.0	15.1
September	12.4	17.0	14.3	43.7	8.8	20.0
October	8.7	9.2	7.6	51.0	72.2	47.9
November	1.8	1.8	0.1	41.4	0.0	32.9
December	-1.1	-1.9	-6.6	15.4	12.9	22.5
Mean/Total	5.8	7.9	5.4	437.8	475.9	410.2

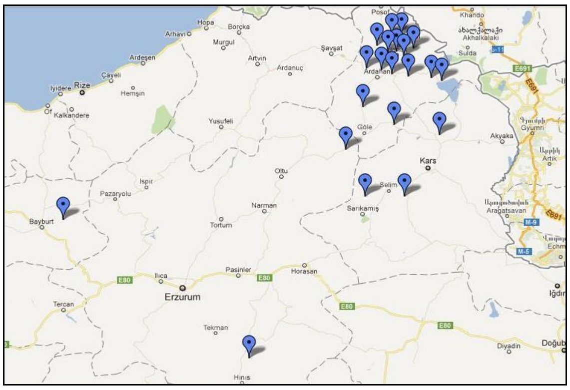

Figure 1. Seed collecting places of the experimental material*

*: Dots show total collecting places

The experiments were arranged in a randomized complete block design with three replications. The seeds were sown by hand with 60 seeds m^{-2} seeding rate in early May in both years (Johnston et al., 2002; Tan and Serin, 2008). The plot size was 3 m x 1.5 m= 4.5 m^2, consisting of 5 rows spaced 30 cm. Forty kg ha^{-1} N and 80 kg ha^{-1} P_2O_5 were applied to experimental area before sowing (Tan and Serin, 2008). Weed control was done by hand hoeing in the end of May. The plot was irrigated 3 times with flooding system when plant color turns dark green during the experiment.

The number of days to maturity was recorded during the harvest. At the pod filling stage, lodging was rated by a 1 to 5 scale, where 1: completely upright and 5: completely lodged (Anonymous, 2001). Ten plants were randomly sampled from each plot near maturity to determine plant height, pod number per plant and seed number per pod characteristics every year. Plots were harvested by hand in the middle of the August in both years when plants reached seed maturity stage. After harvest, all plant samples were dried in the oven at 50 ^{o}C

Table 2. Some morphological properties of pea ecotypes used in the experiment.

Ecotypes	Origine	Flower color	Seed shape	Testa color
Avcilar	Hanak-Ardahan	Purple	Round	Green-brown
Balcesme	Gole-Ardahan	Purple	Dimpled	Green-brown
Damal	Damal-Ardahan	Purple	Dimpled	Green-brown
Camlicatak-2	Merkez-Ardahan	Purple	Round	Green-brown
Eskibeyrehatun	Cıldır-Ardahan	Purple	Angled	Green-brown
Esmepinar	Cıldır-Ardahan	Purple	Dimpled	Green-brown
Golbasi	Susuz-Kars	Purple	Dimpled	Green-brown
Igdir	Selim-Kars	Purple	Dimpled	Green-brown
İncili-1	Aydıntepe-Bayburt	White	Round	Green-yellow
İncili-3	Aydıntepe-Bayburt	Purple	Angled	Green-yellow
Kartalpinari	Merkez-Ardahan	Purple	Dimpled	Green-brown
Koyunpinari	Hanak-Ardahan	Purple	Dimpled	Green-brown
Oburcak	Damal-Ardahan	Purple	Dimpled	Green-brown
Ortakent	Hanak-Ardahan	Purple	Dimpled	Green-brown
Ovacevirme-1	Hınıs-Erzurum	White	Round	Green-brown
Sazlisu	Cıldır-Ardahan	Purple	Dimpled	Green-brown
Serhat	Damal-Ardahan	Purple	Dimpled	Green-brown
Sulakyurt	Merkez-Ardahan	Purple	Round	Green-brown
Senkaya	Senkaya-Erzurum	White	Angled	Green-yellow
Tepekoy	Damal-Ardahan	Purple	Dimpled	Green-brown
Yigitkonagi	Gole-Ardahan	Purple	Dimpled	Green-brown
Yukarisallipinar	Sarıkamış-Kars	Purple	Dimpled	Green-brown

and then weighted to determine total aboveground biomass. Harvested and oven dried material were threshed by hand to separate seeds. After this processes, seed yield and straw yield were calculated. The thousand-kernel weight was estimated by four different samples of 100 seeds for each plot. Harvest index was calculated based on aboveground plant mass as the ratio of seed weight to the total weight of the harvested material.

All data were subjected to analysis of variance based on general linear model for repeated measurement using the SPSS package (SPSS, 1999). Means were separated using Duncan’s Multiple Range Test.

RESULTS AND DISCUSSION

Pea ecotypes had statistically significant differences in plant height, averaging 92.6 cm and it varied from 83.5 and 126.5 cm among ecotypes. Incili-3 ecotypes had the highest plant height in years and average (Table 3). Plant height was shorter in the second year than in the first year. Ecotypes shown different decreases trend in the plant height in the second year, thus plant x year interaction was significant ($P < 0.01$). The experiment established in the spring and warmer weathers prevailed during generative stage of the plant, especially in the second year. Thus, plant height was shorter in the second year in the experiment. On the other hand, the plant height was shorter than previous studies conducted at different locations, especially autumn sown plants (Uzun et al., 2005; Tekeli and Ates, 2003). The reason of these differences can be attributed to shorter growing period as a result of spring sowing. Because pea is a typical cool season plant and its height increases under favorable, cool and moist, conditions (Murray and Swensen, 1985).

Significant differences were observed for days to harvest among ecotypes. Incili-3 ecotype had the longest days to harvest duration in both years. All ecotypes reached the maturity stage earlier in the first year. Favorable ecotypes with respect to seed yield reached the maturity earlier. There were negligible differences among ecotypes with respect to days to harvest between years but these differences caused year x ecotypes interaction ($P < 0.05$). As a result of genetic differences among ecotypes, ecotypes had different day to harvest period. Similar results were also reported for pea (Sayar et al., 2009) and grass pea (Basaran et al., 2011).

Overall, pod number per plant was 12.4 and it showed serious differences among ecotypes (Table 3). According to two years average, Avcilar and Balcesme ecotypes had more pod number per plant than that of the others. Pot number per plant decreased sharply in the second year due to warm weather prevailing generative stage. As is mentioned in the foregoing paragraph, pea is sensitive to high temperature, especially generative stage (Ney et al., 1994). Compared to improved variety, these local ecotypes had enough, even more pod number per plant (Sayar et al., 2009; Karayel and Bozoglu, 2008). There were no significant variation among ecotypes with respect to seed number per pod but the plants had more seed per pod in the second year. These increases most probably stemmed from decreasing pod number per plant.

Significant lodging score differences were observed among ecotypes and years. There was no upright ecotype in the ecotypes observed. Lodging problem increased in the second year due to hail cases. Investigated ecotypes showed serious lodging problems. Lodging is a serious problem in pea and its severity increase after flowering (Stelling, 1997; Uzun et al., 2005). There were no

Table 3. Plant height, days to harvest, pod number and seed number per pod of pea ecotypes

Ecotypes		Plant height (cm)	Days to harvest (day)	Pod number	Seed number per pod
Avcilar		88.0	102.5	15.2	5.1
Balcesme		84.5	103.5	15.5	4.1
Damal		87.0	104.0	12.2	4.4
Camlicatak-2		84.0	102.0	13.0	3.9
Eskibeyrehatun		92.5	106.5	12.2	4.7
Esmepinar		87.5	102.0	11.9	4.6
Golbasi		104.0	111.5	10.5	4.0
Igdir		98.0	106.5	12.2	5.0
Incili-1		106.5	110.5	10.4	4.6
Incili-3		126.5	116.5	11.2	3.9
Kartalpinari		83.5	107.0	11.9	4.0
Koyunpinari		92.0	107.0	13.8	4.6
Oburcak		88.0	103.0	12.0	4.4
Ortakent		90.0	103.5	12.0	4.3
Ovacevirme-1		98.0	106.0	11.2	3.7
Sazlisu		89.5	106.0	12.2	4.0
Serhat		88.5	105.0	11.0	3.5
Sulakyurt		90.0	104.5	12.8	5.4
Senkaya		88.0	108.0	13.2	5.1
Tepekoy		83.5	103.0	10.5	4.1
Yigitkonagi		89.0	106.5	14.7	5.6
Yukarisallipinar		98.5	104.5	12.9	4.9
Mean		92.6	106.0	12.4	4.5
LSD		8.2	2.5	1.8	-
Years	2009	101.8	100.4	15.7	3.8
	2010	83.4	111.4	9.0	5.1
LSD		2.5	0.75	0.5	0.2
F-test					
Years (Y)		**	*	*	*
Ecotypes (E)		**	*	*	ns
Y x E		**	*	*	ns

ns: not significant, **F*-test significant at $P \leq 0,05$, ***F*-test significant at $P \leq 0.01$

promised materials with respect to the lack of lodging problem among investigated ecotypes.

The ecotypes showed great variation with respect to thousand kernel weight (Table 3). Incili-1 ecotype had the highest thousand-kernel weight (227.4 g) while Yigitkonagi ecotype had the lowest thousand-kernel weight (67.3 g). Thousand-kernel weight showed a decreasing trend in all ecotypes but the decreasing trend was different among ecotypes. Hence, year x ecotypes interaction was significant ($P < 0.05$). Several studies with pea showed that they are particularly sensitive to high temperature during the generative stage (Ney et al., 1993; Biarnes-Dumolin et al., 1996; Uzun et al., 2005), therefore, seed size decreased in the second year due to high temperature during June and July.

An analysis of variance indicated that there were significant ($P < 0.05$) different straw yield performances among ecotypes in individual years and overall, and year x ecotypes interaction was significant ($P < 0.05$). But there were no significant differences between years. Incili-3 ecotypes had the highest straw yield performance among ecotypes. The ecotypes having the highest seed yield performance and good stability ability between years, Avcilar and Ortakent, had lower straw yield performance than Incili-3 but they had higher performance than vast majority of the other ecotypes (Table 4). Their straw yield performances were quite stable against years, whereas, Incili-3 showed different straw yield performance between years. Straw is used commonly as animal feed in winter feeding program in the region (Avcioglu et al., 2000), hence, sustainable straw production together higher seed yield is a desirable properties in grain crop production in the region. The favorable ecotypes in this study given equal or higher straw yield compared to the other annual legumes (Tan and Serin, 1995; Serin et al., 1997).

On average, seed yield was 1.73 t ha^{-1} and it was changed between 1.50 and 2.21 t ha^{-1} among ecotypes (Table 4). Seed yield was higher in the first experimental year than the second year. Ecotypes showed different yield performance between years. While Avcilar and Ortakent ecotypes had similar yield performance in the both years, Incili-3 and Oburcak ecotypes had higher yield performance in the second experimental years but the other ecotypes showed incompatible yield performance between years. Warmer weather condition and hail cases must be responsible for decreasing seed yield performance in the second experimental year because high temperature during flowering and pod formation cause decrease in seed yield in pea (Acikgoz et al., 2009). Incompatibility in yield performance among ecotypes with respect to years was responsible for years x ecotype interaction (Figure 2).

Although four ecotypes (Ortakent, Golbasi, Balcesme and Avcilar) had superior yield performance on average, the yield performance of Golbasi and Balcesme ecotypes showed great variation between years. Yield performance of plants is controlled by genetic capacity of a plant, environment and their interaction (Fehr, 1993). High and stable seed yield performances are the main objectives in plant breeding programs. To be widely accepted, a genotype must show good performance across a range of environments (Acikgoz et al., 2009) Genotypes respond to changes in environmental conditions such as temperature, rainfall, soil type, moisture and so on (Fehr, 1993). Avcilar and Ortakent ecotypes must be more stable against environmental condition than Golbasi and Balcesme ecotypes, hence Avcilar and Ortakent ecotypes can be considered for further investigation with respect to seed production for new variety development.

Table 4. Lodging score, 1000-kernel weight, straw yield, seed yield and harvest index of pea ecotypes

Ecotypes		Lodging score	1000 kernel weight (g)	Straw yield (t ha^{-1})	Seed yield (t ha^{-1})	Harvest index (%)
Avcilar		3.7	76.3	4.05	1.91	32.1
Balçeşme		3.9	73.2	4.27	1.91	30.8
Damal		3.7	67.9	3.73	1.85	33.2
Camlicatak-2		3.9	74.9	4.21	1.61	27.5
Eskibeyrehatun		4.0	77.2	3.91	1.56	28.5
Esmepinar		3.0	76.0	3.99	1.70	29.7
Golbasi		3.4	131.7	4.00	1.96	32.8
Igdir		3.2	92.4	4.05	1.70	29.5
Incili-1		3.5	227.4	3.74	1.78	32.3
Incili-3		3.9	115.7	4.53	1.73	27.7
Kartalpinari		3.8	75.6	3.94	1.61	29.4
Koyunpinari		4.0	86.9	3.79	1.55	29.1
Oburcak		4.4	76.7	3.65	1.85	33.6
Ortakent		3.5	82.9	3.96	2.21	35.9
Ovacevirme-1		3.7	132.7	3.35	1.58	32.4
Sazlisu		3.3	87.5	4.16	1.69	28.9
Serhat		3.7	69.3	3.66	1.67	31.4
Sulakyurt		3.5	70.8	4.09	1.82	31.1
Senkaya		3.5	100.7	3.37	1.64	32.6
Tepekoy		4.0	76.4	3.78	1.72	31.4
Yigitkonagi		3.5	67.3	4.10	1.59	27.6
Yukarisallipinar		4.0	82.5	3.89	1.50	27.8
Mean		3.7	91.9	3.92	1.73	30.7
LSD		0.8	10.1	0.34	0.34	3.7
Years	2009	3.3	99.3	3.77	1.90	33.7
	2010	4.1	84.5	4.07	1.56	27.7
LSD		0.2	2.3	-	0.10	1.1
F-test						
Years (Y)		*	*	ns	**	*
Ecotypes (E)		*	**	*	**	*
Y x E		ns	**	*	*	ns

ns: not significant, **F*-test significant at P ≤ 0,05, ***F*-test significant at P ≤ 0.01

Harvest index varied from 27.5 to 35.9 among ecotypes (Table 4). Although some ecotypes had statistically similar to Ortakent ecotype's harvest index value, Ortakent ecotype had the highest harvest index value. Harvest index of the ecotypes decreased in the second experimental year. This situation most probably stemmed from hail damage which it occurred generative stage in the second year. The studies conducted under different ecological condition with different pea variety have shown that harvest index changed between 30 and 60 % (Martin et al., 1994; Uzun and Acikgoz, 1998 Uzun et al., 2005). Harvest index values might be comparable with the earlier findings.

In conclusion, based on yield and yield component values in this experiment conducted for two years under

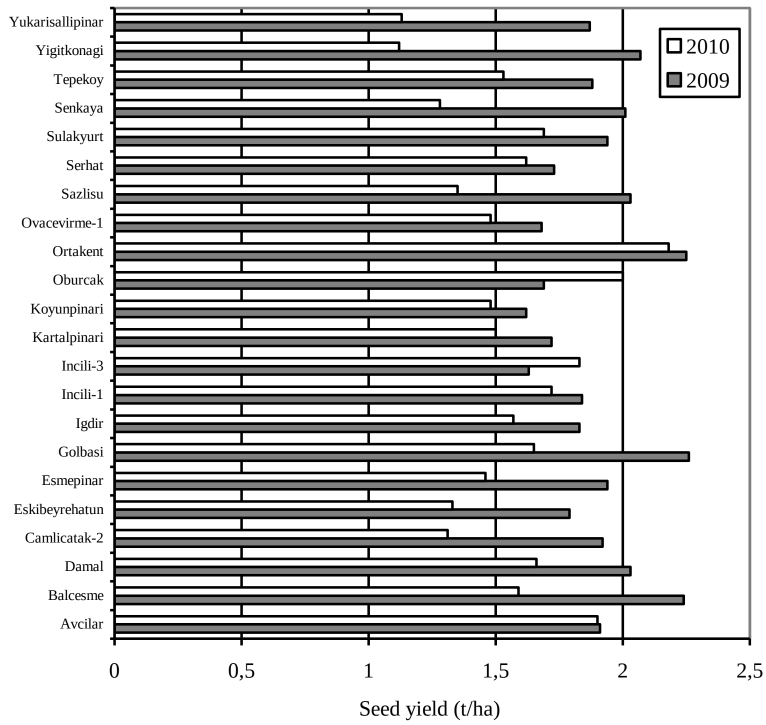

Figure 2. Changes of seed yield depending on years among ecotypes (LSD:)

Erzurum ecological condition, Avcilar and Ortakent ecotypes can be considered promising ecotypes for cultivar development. Although Balcesme and Golbasi ecotypes had statistically similar seed yield performance on average of the years they showed great variation across the years. Hence, these two ecotypes need further breeding studies to increase stability. Therefore, Avcilar and Ortakent ecotypes should be used in location trials in order to develop new variety for seed production.

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LITERATURE CITED

Acikgoz, E, A. Uzun, 1997. Some agronomic and morphological traits of hybrid lines developed from semi-leafless and leafed pea (*Pisum sativum* L.) varieties. 2nd National Field Crop Cong, September 25-27, 1997, Samsun, Turkey, p: 436-440.

Acikgoz, E., A. Ustun, I. Gul, E. Anlarsal, A. S. Tekeli, I. Nizam, R. Avcioglu, H. Geren, S. Cakmakci, B. Aydinoglu, C. Yucel, M. Avci, Z. Acar, I. Ayan, A. Uzun, U. Bilgili, M. Sincik, M. Yavuz, 2009. Genotype× environment interaction and stability analysis for drymatter and seed yield in field pea (*Pisum sativum* L.). Span J. Agric. Res. 7: 96-106

Acikgoz, E., 2001. Forage Crops. Uludag Univ. Publ. No: 182, Bursa, Turkey, 584 p.

Acikgoz, E, V. Katkat, S. Omeroglu, B. Okan, 1985. Mineral elements and amino acid concentrations in field pea and common vetch herbages and seeds. J. Agron. Crop Sci. 55: 179-185.

Anonymous, 2001. Technical Instructions on VCU Tests. Turkey Agriculture and Rural Ministry, Variety Registration and Seed Certification Centre. Ankara,Turkey.

Anonymous, 2010. Erzurum Meteorological Station Records. Erzurum, Turkey.

Avcioglu, R, H. Soya, E. Acikgoz, A. Tan, 2000. Forage production. 5th National Tech. Cong. on Agric., January 17-21, 2000, Ankara, Turkey, p: 567-584.

Basaran, U., H. Mut, O. Onal-Asci, Z. Acar, I Ayan, 2011. Variability in forage quality of Turkish grass pea (*Lathyrus sativus* L.) landrace. Turk J. Field Crops 16: 9-14.

Biarnes-Dumoulin, V, J.B. Denis, I. Lejeunehenaut, G. Eteve, 1996. Interpreting yield instability in pea using genotypic and environmental covarates. Crop Sci. 36: 15-120.

Bilgili, U., E. Acikgoz, 1999. A research on the important morphological and agronomic characters of near izogenic lines of forage pea with different leaf forms. 3rd National Field Crop Cong., November 15-18, 1999, Adana, Turkey, p: 96-101.

Bourdillon, A., 1999. Advantages and constraints of grain legume for the feed market. Proc. the Third Eur. Conf. on Grain Legumes, Valladolid, Spain, 1988, Paris, France, p: 5-6.

Fehr, W.R., 1993. Principles of Cultivar Development. I. Theory and Technique. Macmillan Comp Inc, Ames, Iowa, USA, 536 P.

Johnston, A.M., G.W. Clayton, G.P. Lafond, K.N. Harker, T.J. Hogg, E.N. Johnson, W.E. May, J.T. McConnell, 2002. Field pea seeding management. Can. J. Plant Sci. 82: 639-644.

Karayel, R., H. Bozoglu, 2008. Some agronomic properties of local pea population collected from different areas of Turkiye. J. Fac. Agric. OMU 23: 32-38.

Knauft, D.A., F.P. Gardner, 1998. Diversity and genetics in the development of crop species. In: Principles of ecology in plant production (Ed. Sinclair TR, Gardner FP). Oxford Univ Press Oxford, p: 31-47.

Martin, J., L. Tenorio, I. Ayarbe, 1994. Yield, growth and water-use of conventional and semi-leafless peas in semiarid environments. Crop Sci. 34: 1576-1583.

McKenzie, D.B., D. Spooner, 1999. White lupin: An alternative to pea in oat-legume forage mixtures grown in New Foundland. Can. J. Plant Sci. 79: 43-47.

Murray, G.A., J.B. Swensen, 1985. Seed yield of Austrian winter field peas intercropped with winter cereals. Agron. J. 77: 913-916.

Ney, B., C. Duthion, O. Turc, 1994. Phenological response of pea to water stress during reproductive development. Crop Sci. 34: 141-146.

Ney, B., C. Duthion, E. Fontaine, 1993. Timing of reproductive abortions in relation to cel division, water content and growth of pea seeds. Crop Sci. 33: 267-270.

Santalla, M., J.M. Amurrio, A.M. De Ron, 2001. Food and feed potential breeding value of green, dry and vegetable peagermplasm. Can. J. Plant Sci. 81: 601-610.

Sayar, M.S., A.E. Anlarsal, M. Basbag, I. Gul, E. Acikgoz, 2009. The determination of yield and yield components of some forage pea (*Pisum arvanse* L.) lines in Diyarbakir Conditions. 8th National Field Crop Cong, October 19-22, Hatay, Turkey, p: 646-650.

Serin, Y., M. Tan, H.B. Celebi, 1997. Determination of suitable bittervetch (*Vicia ervilia* (L.) Willd.) lines in Erzurum conditions. J. Field Crops Cent. Res. Inst. 6: 13-22.

SPSS, 1999. Base 9.0 for Windows Users Guide. SPSS Inc, USA.

Stelling, D., 1997. Dry peas (*Pisum sativum* L.) grown in mixtures with faba beans (*Vicia faba* L.)-A rewarding cultivation alternative, J. Agric. Crop Sci. 179: 65-74.

Tan, M., Y. Serin, 1995. The effects of Rhizobium inoculation and nitrogen fertilization on hay, seed, straw and crude protein yield, crude protein content and nodule number of common vetch (*Vicia sativa* L.) in Erzurum irrigated conditions. Turk. J. Agric. and For. 19: 137-144.

Tan, M., Y. Serin, 2008. Forage Legumes. Atatürk Univ. Fac of Agric. Pub. No: 190, Erzurum, Turkey.

Tekeli, A.S., E. Ates, 2003. Yield and its components in field pea (*Pisum arvense* L.) lines. J. Cent. Eur. Agric. 4: 313-317.

Timuragaoglu, K.A., A. Genc, S. Altınok, 2004. A research on forage and seed yields of forage pea lines under Ankara conditions. J. Agric. Sci. Ankara Univ. 10: 457-461.

Uzun, A., E. Acikgoz, 1998. Effect of sowing season and seeding rate on the morphological traits and yields in pea cultivars of differing leaf types. J. Agron. Crop Sci. 181: 215-222

Uzun, A., U. Bilgili, M. Sincik, I. Filya, E. Açıkgöz, 2005. Yield and quality performances of forage type pea strains contrasting leaf types. Eur. J. Agron. 22: 85-94.