Turkish Journal of Field Crops, 2011, 16(1): 9-14

VARIABILITY IN FORAGE QUALITY OF TURKISH GRASS PEA (*Lathyrus sativus* L.) LANDRACES

Uğur BAŞARAN[1] Hanife MUT[1] Özlem ÖNAL-AŞCI[2] Zeki ACAR[3] İlknur AYAN[3]

[1] *Bozok University, Faculty of Agriculture, Department of Field Crops, Turkey*
[2] *Ordu University, Faculty of Agriculture, Department of Field Crops, Turkey*
[3] *Ondokuz Mayıs University, Faculty of Agriculture, Department of Field Crops, Turkey*

Received: 31.10.2010

ABSTRACT

In this study, variation regarding the days from sowing to 50% flowering stage (FL); dry weight at 50% flowering stage (DW); and contents of crude protein (CP), calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P), acid detergent fiber (ADF), neutral detergent fiber (NDF), and dry matter digestibility (DDM), dry matter intake (DMI), relative feed value (RFV), Ca/P ratio and K/(Ca+Mg) ratio characteristics in hay were investigated in 56 grass pea (*Lathyrus sativus* L.) accessions comprice of 51 Turkish landraces, one released variety 'Gürbüz-2001', and 4 ICARDA lines (560, 564, 565, 566) in 2007-2008 and 2008-2009 growing seasons. Number of the days to 50% flowering was between 174 and 184, and plant dry weight was between 7.63 and 25.52 g amongst grass pea accessions. The range in hay was 20.95 – 26.31% for CP, 28.80 – 34.40% for ADF, 33.42 – 45.01% for NDF and 129 - 185 for RFV amongst accessions. In general, while hay of landraces had higher CP, Ca, Mg, K and P content and RFV than ICARDA lines and released variety, the earliest accession was Gürbüz-2001 variety. Landraces N2, D1 and BR1 were the most promising accessions for hay production or breeding for their CP, ADF, NDF contents, RFV value and yield.

Key words: *Lathyrus sativus* L., landrace, forage quality, relative feed value, crude protein

INTRODUCTION

Lathyrus sativus (in Turkish 'mürdümük') is the most economically important and widely cultivated species of the *Lathyrus* genus belonging *Fabaceae* family. Grass pea withstands prolonged drought during grain-filling and heavy rains in early growth stages (Campbell et al., 1994) and, can be grown on wide range of soil types (Abd-El Moneim et al., 2001) without expensive inputs (Croft et al., 1999). Grass pea is grown as a forage crop and also, its grain is used for human consumption and as a stock feed (Skiba et al., 2007). The crop was commonly grown for human consumption in India, Bangladesh, Nepal, Pakistan and Ethiopia (Campbell 1997), and as a fodder crop in Australia, Europe and North America (Siddique et al., 1999).

Although the obvious advantages of grass pea, until recently relatively little effort has been made towards the improvement of this hardy crop (Abd El Monim et al., 2001). Grass pea is gaining interest in Mediterranean type environments to cover marginal lands and to use in crop rotation (Hanbury et al. 1999; Polignano et al. 2009), and also in Europe (Vaz patto et al., 2006).

In Turkey grass pea is cultivated in 18.000 ha (TUIK, 2008) and mostly used as stock- feed, fodder and rarely human consumption (Basaran et al., 2010). However, there is only one registered variety in Turkey and so, farmers sow generally landraces. Although grass pea cultivation has significantly increased as forage due to the government supports, there are few studies (Karadag et al. 2004; Yolcu et al. 2009a; Kiraz 2011) on forage quality of grass pea in Turkey. In addition, landraces of grass pea cultivated in Turkey have not been previously screened in terms of forage quality.

The aims of this study were to examine the variation among the Turkish landraces of grass pea regarding phenology, hay yield, and hay quality traits at 50% flowering stage.

MATERIAL AND METHOD

Fifty one Turkish landraces, Gürbüz-2001 variety and four ICARDA lines (560, 564, 565, 566) of *Lathyrus sativus* were investigated for forage quality at 50% flowering stage. Landraces of grass pea were collected from nine cities (Adiyaman, Burdur, Bursa, Cankiri, Denizli, Elazig, Kutahya, Malatya, Nevsehir, Samsun, Usak) located different regions of Turkey in 2007. Field experiments were conducted in Agricultural Faculty experiment field of Ondokuz Mayis University, Samsun (264972E - 4581185N, UTM), Turkey in 2007-2008 and 2008-2009 growing seasons. Slope is 2 % and altitude is 158 m. Soil analysis was done in soil laboratory of Soil Science Department. Soil contents clay with approximately 2.93% organic matter, phosphorus content 22.89 ppm, potassium content 84.44 ppm, and pH: 6.86. Long term (1974-2009) annual rainfall and mean temperature of experimental area 680.9 mm and 14.3 ^{0}C respectively. Average temperature and total rainfall in growing period (November-June) in 2008 and 2009 ranges between 11.2 and 11.9 ^{0}C, and 437.8 and 541.2 mm, respectively (Anon, 2009).

The field experiment was established on November 19 in the first year and on November 12 in the second year with no fertilizer. Sowing was done by hand at 15 cm seed to seed and 30 cm row to row spacing. One plot (3 m length with 3 rows) was formed for each landrace or line, and randomly five plants were harvested from each plot at 50% flowering stage. Then plant samples were dried at 60 ^{0}C in oven until the constant weight. After cooling and weighing the plants ground to pass though 1 mm screen and mixed. Crude Protein (CP), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), Ca, P, Mg and P content of samples were determined by using Near Reflectance Spectroscopy (NIRS, 'Foss 6500') with software package program 'IC-0904FE'. Relative Feed Value (RFV) of samples was calculated from their predicted Dry Matter Digestibility (DDM) and Dry Matter Intake (DMI) (Rohweder et al., 1978). Quality standards of legume hays are given in Table 1. All the data were presented as a mean, minimum, maximum, and standard deviation determined by using SPSS 13.0 Statistical Package Program. Principle Component Analysis was performed by means of SPSS 10.0 V. This study was repeated two years, and the results were given as a mean of two years.

Table 1. Legume, grass and legume-grass mixture quality standards

Quality Standard*	**CP, % of DM**	**ADF, % of DM**	**NDF, % of DM**	**RFV****
Prime	>19	<31	<40	>151
1 (Premium)	17-19	31-40	40-46	151-125
2 (Good)	14-16	36-40	47-53	124-103
3 (Fair)	11-13	41-42	54-60	102-87
4 (Poor)	8-10	43-45	61-65	86-75
5 (Reject)	<8	>45	>65	<75

* Standard assigned by Hay Market Task Force of American Forage and Grassland Council
** Relative Feed Value (RFV)-Reference hay of 100 RFV contains 41 % ADF and 53 % NDF
RFV = (%DDM * %DMI) /1.29; % DDM = 88.9 - (0.779 x %ADF); DMI % of BW = 120 / %NDF;
DDM = Dry matter digestibility, ADF = Acid detergent fibre (% of DM), DMI = Dry matter intake (% of BW)

RESULTS AND DISCUSSION

The values about phenology, yield, chemical composition and Relative Feed Value (RFV) of grass pea landraces and lines are given in Table 2. Days from sowing to %50 flowering (FL) varied from 174 to 184 days with average 179 days among genotypes. The earliest genotype for FL was Gürbüz, and latest was landrace S. Our results for FL was significantly higher than reported by De La Rosa and Martin (2001) and Polignano et al. (2009) who found that FL varied 143 to 154 days and 117 to 120 days in grass pea lines respectively, possibly due to ecological and genetic differences. The dry weight (DW) changed between 7.63 – 25.52 g/plant and, it was 9.92 g/plant as a mean**.** Lowest DW was in landraces A1, and highest in landraces N2 (Table 2). Mikic et al. (2010) reported that DW varied 4.51- 8.18 g/plant in four French landrace of grass pea. Our results were generally higher than Mikic et al. (2010). This situation could be due to different ecological conditions (air temperature, precipitation and soil), genetic variance and capability.

Also there was big variability amongst the grass pea accessions in terms of chemical composition of hay including crude protein (CP), Ca, Mg, K, P (Table2). Crude protein content of grass pea accessions varied from 20.95 to 26.31% with a mean of 23.46%. The minimum CP content in ruminant diet should be around 6.0 - 8.0% of dry matter for adequate activity of rumen microorganism (Van Soest 1994), suggesting that hay CP content in investigated grass peas are more than twice or thrice needed ratios. The mean CP content was considerably higher than reported by Kiraz (2011), Karadag and Buyukburc (2004) and Poland et al. (2003) who found that CP contents of grass pea samples were 22.13, 21.87 and 18.20%, respectively.

The mineral nutrition content of grass pea accessions were between 1.42 - 1.69%, 0.26 – 0.35%, 1.67 – 2.33% and 0.34 – 0.40% for Ca, Mg, K and P respectively. It has been reported that the requirements for gestating or lactating beef are 0.18-0.44% for Ca, 0.04-0.1 % for Mg, 0.6-0.8% for K and 0.18 – 0.39% for P (NRC 1996; Tekeli and Ates 2005). Tajeda et al. (1985), reported that forage should contain at the level of 0.2% Mg and at least 0.3% Ca for the ruminant. For this respect, while determined ratios of Ca, Mg and K were very high, P was similar compared to recommended ratios in hay. On the other hand the Ca, Mg, P, K contents of grass pea hay were higher than that reported by Yolcu et al. (2009b) who found that Ca, Mg, P and K content were approximately 0.7, 0.25, 0.25 and 1.12% respectively, in grass pea hay.

The ratios of Ca/P and K/(Ca+Mg) calculated in the grass pea landraces or lines are given in Table2. The values calculated in the grass pea accessions varied from 3.54 to 4.82 for Ca/P and 0.9 to 1.33 for K/(Ca+Mg). In order to keep good animal health, the balance of mineral nutrient elements in forage or animal diet is very important, and these elements could be in certain ratio (Abbasi et al., 2009). A recommended ratio of Ca/P is between 1 and 2 (Miller and Reetz, 1995). If this ratio is over 2.0, probably milk fewer is seen in livestock (Acıkgoz, 2001). Similarly, Ayan et al. (2010) reported that K/(Ca+Mg) should not exceed 2.2 in forage. The value 2.2 or greater in forage can cause tetany (Jefferson et al., 2001). Our results indicated that K/(Ca+Mg) ratios for all grass pea accessions were under level of tetany. But Ca/P ratios were higher than required value because of low P content. This situation can be attributed to the soil of experiment area. So, this problem may be solved with suitable fertilization with phosphorus.

Table 2. Phenology, yield, chemical composition and Relative Feed Value (RFV) of grass pea hay

Accession*	FL (day)	DW (g/plant)	CP (%)	Ca (%)	Mg (%)	K (%)	P (%)	Ca/P	K/ (Ca+Mg)	ADF (%)	NDF (%)	DDM (%)	DMI (%)	RFV
A1	177.00	7.63	23.07	1.50	0.29	2.00	0.36	4.14	1.12	31.92	40.53	64.0	3.0	147
A2	178.00	8.43	23.23	1.50	0.29	1.96	0.37	4.01	1.10	31.77	40.28	64.1	3.0	148
B1	178.00	8.37	21.95	1.53	0.29	1.93	0.35	4.38	1.06	32.04	42.75	63.9	2.8	139
B2	180.50	9.96	24.01	1.56	0.31	2.03	0.38	4.12	1.08	31.62	40.92	64.3	2.9	146
B3	179.50	8.93	23.29	1.58	0.29	1.86	0.36	4.45	1.00	32.60	41.78	63.5	2.9	141
BR1	182.00	10.16	26.20	1.59	0.31	1.91	0.39	4.08	1.00	30.10	38.74	65.5	3.1	157
BR2	182.00	10.67	26.02	1.60	0.31	1.74	0.39	4.08	0.91	31.24	40.98	64.6	2.9	146
BR3	182.00	11.01	24.92	1.69	0.35	1.83	0.38	4.40	0.90	31.29	40.26	64.5	3.0	149
BR4	181.50	13.00	22.55	1.50	0.31	1.68	0.36	4.20	0.93	34.07	44.67	62.4	2.7	130
C1	180.50	9.12	22.42	1.44	0.27	2.18	0.38	3.83	1.27	32.54	40.32	63.6	3.0	147
C2	179.00	12.98	22.63	1.52	0.28	2.03	0.37	4.08	1.13	32.18	40.22	63.8	3.0	148
C3	180.00	8.72	22.53	1.49	0.26	2.18	0.38	3.96	1.25	31.77	39.71	64.1	3.0	150
D1	178.50	9.91	25.27	1.48	0.27	2.33	0.39	3.76	1.33	30.00	36.36	65.5	3.3	168
D2	178.00	9.14	23.69	1.58	0.31	2.02	0.37	4.24	1.07	30.11	38.57	65.4	3.1	158
D3	178.50	8.76	24.39	1.58	0.28	1.94	0.38	4.15	1.04	31.71	40.21	64.2	3.0	149
D4	178.00	9.45	21.42	1.51	0.29	1.92	0.36	4.22	1.07	33.24	42.27	63.0	2.8	139
D5	179.50	8.50	22.46	1.57	0.33	1.95	0.35	4.50	1.03	32.42	41.97	63.6	2.9	141
D6	178.50	9.80	23.09	1.53	0.28	2.06	0.37	4.14	1.14	31.94	40.01	64.0	3.0	149
D7	178.50	8.27	23.47	1.56	0.30	1.94	0.36	4.34	1.05	31.57	40.52	64.3	3.0	148
D8	177.50	8.56	21.85	1.49	0.30	1.95	0.35	4.21	1.09	34.11	45.01	62.3	2.7	129
E1	177.00	10.65	22.28	1.42	0.27	2.04	0.40	3.54	1.20	33.31	40.40	63.0	3.0	145
E2	178.50	8.24	21.40	1.58	0.31	1.71	0.34	4.62	0.90	33.80	44.05	62.6	2.7	132
E3	178.50	8.26	21.76	1.57	0.31	1.88	0.34	4.64	1.00	31.37	39.88	64.5	3.0	150
K	178.50	11.42	24.22	1.60	0.32	1.74	0.36	4.38	0.91	31.63	41.16	64.3	2.9	145
M1	177.00	9.81	23.83	1.44	0.28	2.12	0.39	3.68	1.23	30.94	37.75	64.8	3.2	160
M2	177.00	11.51	22.37	1.50	0.29	2.01	0.35	4.27	1.12	33.81	42.30	62.6	2.8	138
M3	177.00	9.06	23.08	1.49	0.28	2.03	0.37	4.03	1.15	33.38	40.42	62.9	3.0	145
M4	178.00	10.19	20.99	1.44	0.28	1.94	0.35	4.13	1.13	34.40	42.77	62.1	2.8	135
N1	179.00	14.97	23.91	1.45	0.28	2.24	0.39	3.71	1.29	32.20	39.15	63.8	3.1	152
N2	179.00	25.52	26.31	1.52	0.27	2.11	0.40	3.79	1.17	28.80	33.42	66.5	3.6	185
N3	179.00	10.29	23.35	1.49	0.28	2.08	0.38	3.97	1.17	32.63	41.67	63.5	2.9	142
N4	178.50	10.34	23.14	1.42	0.28	2.20	0.39	3.67	1.30	32.33	39.85	63.7	3.0	149
N5	178.00	8.83	20.95	1.54	0.30	1.80	0.34	4.53	0.98	32.90	42.64	63.3	2.8	138
N6	178.50	9.74	22.30	1.52	0.28	2.03	0.38	4.04	1.12	32.50	42.06	63.6	2.9	141
S	184.00	11.19	24.87	1.47	0.27	1.67	0.39	3.78	0.96	31.74	40.56	64.2	3.0	147
U1	180.50	8.01	23.55	1.68	0.31	1.97	0.35	4.82	0.99	30.58	40.78	65.1	2.9	148
U2	179.00	8.97	24.73	1.58	0.29	2.13	0.37	4.28	1.14	29.61	39.24	65.8	3.1	156
U3	177.50	9.02	23.67	1.58	0.30	2.12	0.35	4.45	1.13	31.31	40.42	64.5	3.0	148
U4	177.50	10.38	24.52	1.57	0.31	2.08	0.38	4.17	1.11	30.89	38.56	64.8	3.1	156
U5	179.50	8.90	23.57	1.61	0.30	1.93	0.37	4.37	1.01	30.92	40.83	64.8	2.9	147
U6	179.50	9.24	24.17	1.61	0.33	1.83	0.37	4.39	0.94	31.74	41.36	64.2	2.9	144
U7	180.50	8.74	24.57	1.64	0.32	1.84	0.38	4.37	0.94	30.66	39.37	65.0	3.0	153
U8	179.50	9.10	24.44	1.59	0.30	1.82	0.37	4.30	0.96	32.05	42.23	63.9	2.8	141
U9	180.50	7.94	23.57	1.51	0.32	1.98	0.36	4.25	1.08	31.84	40.86	64.1	2.9	146
U10	179.50	8.98	23.28	1.60	0.32	1.92	0.35	4.55	1.00	29.43	39.60	66.0	3.0	155
U11	180.00	8.95	24.25	1.60	0.31	1.97	0.36	4.41	1.03	30.38	39.51	65.2	3.0	153
U12	180.50	8.08	25.34	1.58	0.29	2.05	0.38	4.19	1.09	30.36	38.70	65.2	3.1	157
U13	178.50	8.97	24.13	1.63	0.32	1.84	0.36	4.48	0.95	31.44	40.76	64.4	2.9	147
U14	178.50	9.28	25.04	1.63	0.33	1.97	0.38	4.30	1.00	30.53	38.71	65.1	3.1	156
U15	178.50	9.34	25.81	1.68	0.32	1.81	0.38	4.45	0.90	30.15	38.98	65.4	3.1	156
U16	179.50	8.39	25.05	1.68	0.33	1.87	0.37	4.51	0.93	30.19	39.01	65.4	3.1	156
I1 (560)	179.00	10.58	22.32	1.58	0.29	1.73	0.36	4.41	0.92	32.15	41.17	63.9	2.9	144
I2 (564)	179.00	11.97	22.26	1.55	0.29	1.78	0.35	4.37	0.97	33.77	42.40	62.6	2.8	137
I3 (566)	178.50	11.38	21.25	1.45	0.27	1.87	0.36	4.03	1.08	34.25	43.46	62.2	2.8	133
I4 (565)	178.00	9.48	21.54	1.56	0.30	1.88	0.35	4.49	1.01	33.04	42.26	63.2	2.8	139
GR	174.00	8.71	23.25	1.52	0.28	1.96	0.36	4.24	1.08	31.86	40.95	64.1	2.9	145
Mean	**179.00**	**9.92**	**23.46**	**1.55**	**0.29**	**1.95**	**0.37**	**4.21**	**1.06**	**31.81**	**40.60**	**64.1**	**3.0**	**147**
Min	174.00	7.63	20.95	1.42	0.26	1.67	0.34	3.54	0.90	28.80	33.42	62.1	2.7	129

Table 2 (Continued)

Accession*	FL (day)	DW (g/plant)	CP (%)	Ca (%)	Mg (%)	K (%)	P (%)	Ca/P	K/ (Ca+Mg)	ADF (%)	NDF (%)	DDM (%)	DMI (%)	RFV
Max	184.00	25.52	26.31	1.69	0.35	2.33	0.40	4.82	1.33	34.40	45.01	66.5	3.6	185
Std. dev.	1.58	2.55	1.36	0.067	0.020	0.143	0.01	0.27	0.11	1.31	1.93	1.02	0.15	9.36

* Location or origin; A (Adiyaman), B (Burdur), BR (Bursa), C (Cankiri), D (Denizli), E (Elazig), K (Kutahya), M (Malatya), N (Nevsehir), S (Samsun), U (Usak),
I (ICARDA Line), GR (released species-Gürbuz-2001)
FL: 50% flowering, DW: plant dry weight, CP: crude protein, ADF acid detergent fiber, NDF: neutral detergent fiber, RFV: relative feed value

Average ADF content was 31.81% with a range of 28.80 – 34.40% and, average NDF content was 40.60% with a range of 33.42 - 45.01% among accessions (Table 2). The lowest ADF and NDF were in landrace N2. The highest ADF and NDF were determined in landrace M4 and landrace D8, respectively. Grass pea hay in terms of ADF and NDF content had prime/good quality standards (Table 1). ADF and NDF contents determined in present study are falled within ranges reported in earlier studies (Tuna et al. 2004; Yolcu et al. 2009a; Larbi et al. 2010; Kiraz 2011). On the other hand, range of ADF and NDF in our study is higher than reported for 25 accessions of grass pea (Larbi et al., 2010). This difference could be due to harvest time, different ecological conditions.

DDM, DMI and RFV varied among accessions, due to variations in ADF and NDF (Table 2). ADF and NDF are important quality traits for forage and, increase ADF and NDF causes to decrease digestibility and nutrient availability. The DDM and DMI ratios of grass pea accessions varied from 62.1 to 66.5% and 2.7 to 3.6% respectively. RFV is a index used to predict the intake and energy value of forage and derived from DDM and DMI (Ayan et al., 2010). Forages are classified in six groups regarding to RFV value; forages have the value of RFV > 151 is in prime class (Rohweder et al, 1978). Among investigated grass pea genotypes, RFV value varied between 129 -185 and with a mean of 147, which means all genotypes were in class prime or class 1 and, however, mostly in class prime (Table 1; Figure 1). On the other hand, RFV of ICARDA lines (560,564,565,566) and Gurbuz were under the mean value (Table 2). The highest DDM, DMI and RFV were determined in landraces N2. Mean values of DDM, DMI and RFV determined in current study were approximately consistent with earlier reports (Yolcu et al. 2009a; Kiraz 2011), however, RFV of landraces N2 (185) was higher than those values reported in same reports.

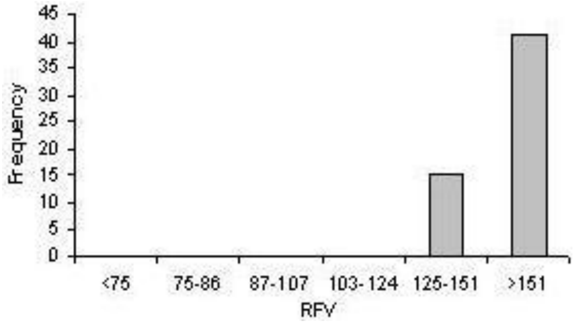

Figure 1. Number of the accession belong to each RFV class

Principle component analysis (PCA) based on phenology, forage yield and quality traits (FL, DW, CP, Ca, K, Mg, P, ADF, NDF and RFV) indicated that the first two principle components explained 70.45% of the total variation (Figure2). The first component explained 43.45% of the variation and, the second component explained 27.00% of the variation. Correlation of the analyzed traits with the first two principle axes was given in Table 3. In the first component the traits with the most important contribution were related to yield (DW) and nutritive value of hay (CP, P, ADF, NDF and RFV). Second component was mainly loaded by traits related to mineral content (Ca, K, Mg).

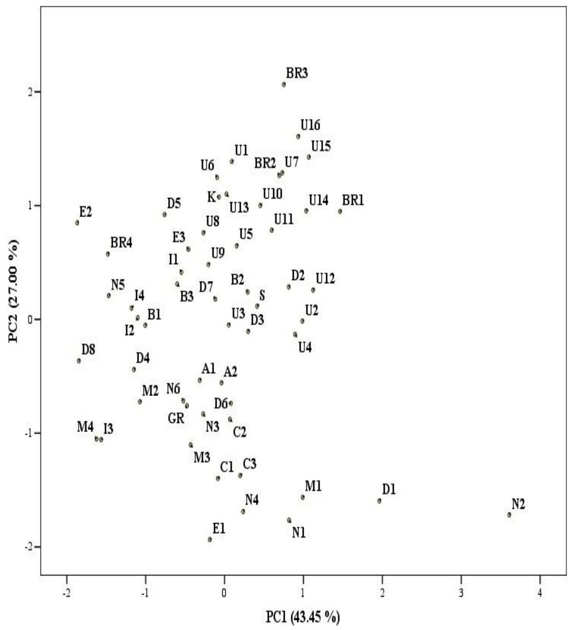

Figure 2. Dispersion of the grass pea genotypes based on the first two principle component

Table 3. Correlation of the analyzed traits with the first two principle component

Traits	Component 1	Component 2
FL	0.25	0.44
DW	**0.41**	-0.34
CP	**0.86**	0.31
Ca	0.25	**0.89**
K	0.40	**-0.68**
Mg	0.01	**0.89**
P	**0.74**	-0.32
ADF	**-0.87**	-0.30
NDF	**-0.94**	0.16
RFV	**0.96**	-0.07
% Variation	43.45	27.00

CONCLUSION

New grass pea varieties with high yield and quality can provide increase in grass pea cultivation in Mediterranean-type climate and contribute to sustainability in dryland agriculture to diversify cropping system based on monoculture cereal production. On the other hand, this crop is arousing interest in many parts of the world due to global climate changes scenario and also many study in progress for its re-introduction in agriculture in Europe.

For breeding study, landraces are an extremely important genetic material to improve new varieties for different purposes, and present study indicated that Turkish landraces of grass pea are promising genotypes especially for breeding forage-type grass pea varieties, since forage quality and yield were generally higher in landraces than in both ICARDA lines and Gürbüz variety. Therefore, landraces N2, D1, BR1 was seen most promising genotypes for forage crop breeding with their high CP contents, RFV value, low ADF and NDF ratios, also high yield.

LITERATURE CITED

Anonymous, 2009. Turkish State Meteorological Services, Samsun Meteorology Regional Directorate, Samsun.

Abbasi, M.K., M.M. Tahır, A.S. Shah, F. Batool. 2009. Mineral nutrient composition of different ecotypes of white clover and their nutrient credit to soil at Rawalakot Azad Jammu and Kashmir. *Pak. J. Bot*., 41(1): 41-51, 2009.

Abd El Moneim, A., B. Van Dorrestein, M. Baum, J. Ryan, G. Bejiga. 2001. Role of ICARDA in improving the nutritional quality and yield potential of grasspea (*Lathyrus sativus* L.), for subsistence farmers in dry areas. *Lathyrus* Lathyrism Newsletter 2 (2), 55–58.

Acıkgoz E., 2001. Forages. Uludag University, Faculty of Agriculture, Department of Field Crops, Bursa-Turkey.

Ayan, I., H. Mut, O. Onal-Asci, U. Basaran, Z. Acar. 2010. Effects of manure application on the chemical composition of rangeland hay. Journal of Animal and Veterinary Advences, 9 (13): 1852-1857.

Basaran, U., Z. Acar, O. Onal Ascı, H. Mut, O. Tongel. 2010. Cultivated local *Lathyrus* varieties in Turkey and their some agronomical traits. The contributions of grasslands to the conservation of Mediterranean biodiversity. C Porqueddu. S. Rios (eds). Zaragoza: CIHEAM/CIBIO/FAO. 2010, 286 p. (Options Méditerranéennes, Series A: Mediterranean Seminars, No. 92) pp. 129-133.

Campbell, C.G., R.B. Mehra, S.K. Agrawal, Y.Z. Chen, A.M. El-Moneim, H.I.T. Khawaja, C.R. Yadov, J.U. Tay, W.A. Araya. 1994. Current status and future strategy in breeding grasspea (*Lathyrus sativus*). Euphytica 73, 167–175.

Campbell, C.G., 1997. Grasspea. *Lathyrus sativus* L. Promoting the conservation and use of underutilized and neglected crops. 18. Institute of Plant Genetics and Crop Plant Research, Gatersleben/ International Plant Genetic Resources Institute, Rome, Italy.

Croft, A.M., E.C.K. Pang, P.W.J. Taylor. 1999. Molecular analysis of *Lathyrus sativus* L. (grasspea) and related *Lathyrus* species, Euphytica 107 (), pp. 167–176.

De La Rosa, L., I. Martin, 2001. Morphological characterization of Spanish genetic resources of *Lathyrus sativus* L. *Lathyrus* Lathyrism Newsletter, 2, 31-34.

Hanbury, C.D., K.H.M. Siddique, N.W. Galwey, P.S. Cooks. 1999. Genotype-environment interaction for seed yield and ODAP concentration of *Lathyrus sativus* L. and *L. cicera* L. in a Mediterranean-type environments. Euphytica 110, 45–60.

Jefferson, P.G., H.F. Mayland,. K.H. Asay, J.D. Berdahl. 2001. Variation in mineral concentration and grass tetany potential among Russian Wildrye Accessions, *Crop Sci.* 41, pp. 543–548.

Karadag, Y., U. Buyukburc, 2004. Forage qualities, forage yields and seed yields of some legume-triticale mixtures under rainfed conditions. Acta Agri. Scan., Sec. B, Soil and Plant Sci. 54: 140-148.

Karadag, Y., S. Iptas, M.Yavuz. 2004. Agronomic potential of grasspea (*Lathyrus sativus*) under rainfed conditions in semi-arid regions of Turkey, Asian J. Plant Sci. 3 (2004), pp. 151–155.

Kiraz, A.B., 2011. Determination of relative feed value of some legume hays harvested at flowering stage. Asian J. Anim. Vet. Adv., 6: 525-530.

Larbi, A., A.M. Abd El-Moneim, H. Nakkoula, B. Jammalb, S. Hassana. 2010. Intra-species variations in yield and quality in *Lathyrus* species: 1. Grasspea (*L. sativus* L.) Animal Feed Science and Technology 161 (2010) 9–18.

Mikic , A., V. Mihailovic, B. Cupina, G. Krstic, S. Vasiljevic, D. Milic. 2010. Forage and seed yield components in four French landraces of grass pea (*Lathyrus sativus* L.). In: Huyghe, C. (Ed.), Sustainable Use of Genetic Diversity in Forage and Turf Breeding. Springer Netherlands, Dordrecht, pp. 127–130.

Miller, D.A., H.F. Reetz-Jr, 1995. Forage fertilization. In: Forages Vol. I: An Introduction to Grassland Agriculture. (Eds.): R.F. Barnes, D.A. Miller and C.J. Nelson. Iowa State Univ. Press, Ames, Iowa, pp. 79-91.

NRC (National Research Council), 1996. Nutrient Requirements of Beef Cattle (7th Ed.) National Academy Press, Washington, D.C.

Poland, C., T. Faller, L. Tisor. 2003. Effect of chickling vetch (*Lathyrus sativus* L.) or alfalfa (*Medicago sativa*) hay in gestation ewe diets. Lathyrus Lathyrism Newsl. 3, 38–40.

Polignano G.B., V. Bisignano, V. Tomaselli, P. Uggenti, V. Alba, C. Della Gatta, 2009. Genotype environment interaction in grass pea (*Lathyrus sativus* L.) lines. Article ID 898396, International Journal of Agronomy p. 7, Avaliable at: http://www.hindawi.com/journals/ija/2009/898396.html (accessed 23.11.2010).

Rohweder, D.A., R.F. Barnes, N. Jorgenson. 1978. Proposed hay grading standards based on laboratory analyses for evaluating quality, Journal of Animal Science 47 (1978), pp. 747–759.

Siddique, K.H.M., S.P. Loss, K.L. Regan, R.L. Jettner. 1999. Adaptation and seed yield of cool season grain legumes in Mediterranean environments of south-western

Australia. Australian Journal of Agricultural Research 50, 375–387.

Skiba, B., A. Gurung, E. Pang, 2007. 'Genome mapping and molecular breeding in *Lathyrus*', in Genome Mapping and Molecular Breeding in Plants. Pulses, Sugar and Tuber Crops. Springer, NewYork, 123 - 131, ISBN: 978-3540345374.

SPSS Inc., 1999. SPSS for Windows. Release 10.0. SPSS Inc., Chicago,USA.

Tejada, R., L.R. McDowell, F.G. Martin, J.H. Conrad. 1985. Mineral element analyses of various tropical forages in Guatemala and their relationship to soil concentrations. Nutrition Reports International, 32: 313-323.

Tekeli, A.S., E. Ates, 2005. Yield potential and mineral composition of white clover (*Trifolium repens* l.)-tall fescue (*Festuca arundinacea* schreb.) mixtures. J. Cent. Eur. Agric., 6: 27-34.

TUIK, 2008. Turkısh Stastical Enstitute, Agiculture statistics (Crop production stataistics, 2008), Avaliable at: http://www.tuik.gov.tr.Tuna, C., L. Coskuntuna, F. Koc. 2004. Determination of nutritional value of some legume and grasses. Pak. J. Biol. Sci., 7: 1750-1753.

Van Soest, P.J., 1994. Nutritional ecology of the ruminant. 2nd edition. Ithaca, New York, USA: Cornell University Press. 476 pp.

Vaz Patto, M.C., B. Skiba, E.C.K. Pang, S.J. Ochatt, F. Lambein, D. Rubiales, 2006. *Lathyrus* improvement for resistance against biotic and abiotic stresses. Euphytica 147, 133–147.

Yolcu, H., M. Dasci, M. Tan, 2009a. Evaluation of annual legumes and barley as sole and intercrop in spring frost condition for animal feeding I. yield end Quality. Journal of Animal and Veterinary Advances 8(7): 1337-1342.

Yolcu, H., A. Gunes, M. Turan, 2009b. Evaluation of annual legumes and barley as sole and intercrop in spring frost condition for animal feeding II. Mineral Composition . Journal of Animal and Veterinary Advances 8(7): 1343-1348