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Full Length Research Paper

Seed yields and biochemical compounds of grasspea (*Lathyrus sativus* L.) lines grown in semi-arid regions of Turkey

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Grasspea (*Lathyrus sativus* L.) is adapted to a wide range of ecological conditions and grow under rainfed conditions. The objective of this study is to investigate the seed yields of grasspea lines and biochemical compounds of seeds grown under rainfed conditions in semi-arid regions of Turkey. Five grasspea lines were obtained from the International Center for Agricultural Research in the Dry Areas (ICARDA) (38, 439, 452, 455 and 463). Field experiments were designed based on randomized block design with three replications during the growing seasons of 2004/05 and 2005/06. Seed yields, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), crude fat (CF) and amino acid (aa) contents of grasspea lines were determined. The seed yields ranged from 1079 to 1583 kg.ha^{-1}, CP content varied from 24.19 to 27.44%, ADF from 5.24 to 7.35%, NDF from 10.18 to 13.55% and CF content from 3.22 to 5.07% based on two-year averages of the experiment.

Key words: Grasspea, crude protein content, neutral detergent fiber content, amino acid.

INTRODUCTION

Profitable livestock production in a farm requires producing its own high quality forages. In the arid and semi-arid regions (mean annual rainfall <400 mm), both grains and straws are used to feed livestock which also graze on non-arable common lands (Acikgoz, 1988; El-Moneim, 1993). The annual average precipitation in approximately 4.5 - 5 million ha of the total agricultural area of Turkey is lower than 400 mm, and 70% of the precipitation falls between December and May (Acikgoz, 1988; Anonymous, 2002). Annual forage legumes need to be introduced in the semi arid regions of Turkey to improve soil fertility and livestock production (Acikgoz, 1988; El-Moneim 1993; Anonymous, 2002). Grain legumes have been recently taken into considerable attention in the central and southeastern areas of Turkey. Vetches (*Vicia* spp.), grasspea (*Lathyrus* spp.), lentil (*Lens culinaris*) and chickpea (*Cicer arietinum*) show good potential due to their resistance to drought and have quite high adaptability to unfavourable environmental conditions (El-Moneim et al., 1990; Thomson et al., 1990; El-Moneim, 1993). The use of legumes as a source of protein in the animal feed industry is expected to increase in the near future (Hanbury et al., 2000).

Legumes have ability to bind the atmospheric nitrogen that reduces the demand for chemical fertilizers and results in obtaining higher seed and hay yields. The seeds of grasspea contain 20 to 40% crude protein (CP) and they are used for both human and animal consumption in the developing countries (El-Moneim and Cocks, 1993; Miyan et al., 1997). Lathyrus species also have potential as pasture plant and have better grazing tolerance as compared to the other grain legumes (El-Moneim and Cocks, 1993).

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Abbreviations: ICARDA, International Center for Agricultural Research in the Dry Areas; **CP,** crude protein; **ADF,** acid detergent fiber; **NDF,** neutral detergent fiber; **CF,** crude fat; **aa,** amino acid.

Table 1. Two years averaged values of seed yield and crude protein content in grasspea lines grown in Kazova-Tokat and Suluova- Amasya during 2004/05 and 2005/06.

Lines	Seed yield (kg.ha^{-1})			Crude protein content (%)		
	Kazova-Tokat	Suluova- Amasya	Mean	Kazova-Tokat	Suluova- Amasya	Mean
452	1592 ab[1]	859 e	1226 b	22.89 d[1]	27.34 ab	25.12 b
439	1912 a	1254 cd	1583 a	25.96 abc	25.07 bc	25.51 ab
455	1556 bc	950 de	1253 b	26.21 abc	26.13 abc	26.17 ab
463	1385 b	773 e	1079 b	24.70 bcd	23.69 cd	24.19 b
38	1610 ab	990 de	1300 ab	28.64 a	26.23 abc	27.44 a
Mean	1611 a[2]	965 b	1288	25.68	25.69	25.69
LSD_{Lo}	20.16**			ns		
LSD_{Ln}	31.87**			2.12*		
LSD_{LoxLn}	33.53*			3.00*		

Lo: Location; Ln: line; LoxLn: line x location interaction * significant at P < 0.05; ** significant at P < 0.01; ns: not significant.
[1] Means of different line-location combinations with the same letter are not statistically significant according to the LSD test at P < 0.05;
[2] means of locations with the same letter are not statistically significant at P < 0.05.

Legumes may grow under several agricultural conditions which affect the seed yield and chemical compound of the plant (Roy, 1981; Milczak et al., 2001). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) values are increased with the temperature, as a result lowering intake and digestions of the animals (Soest et al., 1991, 1994). A higher CP content is important for feeding animal, however the quality of proteins depends on their amino acid content, particularly essential amino acids (Roy, 1981). The objective of this study is to investigate the seed yields of grasspea lines (*Lathyrus sativus* L.) and biochemical compounds of seeds grown under rainfed conditions in semi-arid regions of Turkey.

MATERIALS AND METHODS

The field experiments were conducted at the Field Crops, Department of the Agricultural Faculty of Gaziosmanpasa University, (40°13´ - 40°22´ N, 36°1´ - 36°40´ E, altitute 623 m) in Kazova-Tokat and Suluova-Amasya (40°50' - 40°84' N, 35°38' - 35°64' E, altitute 541 m) during the growing seasons of 2004/05 and 2005/06. Soil samples were collected from 0-20 cm depth. Soils of the experimental areas were slightly alkaline, medium in calcium carbonate and in phosphorus (P_2O_5) contents, high in potassium (K_2O) and poor in organic matter content. Average temperatures of 11.3, 10.8 and 11.5°C were recorded between October and June during 2004/05, 2005/06 and long-term periods in Kazova-Tokat, respectively. Average temperatures of 12.4, 11.4 and 11.9°C were recorded between October and June during 2004/05, 2005/06 and long-term periods in Suluova-Amasya, respectively. Total rainfalls of 508.9, 375.9 and 405.3 mm were recorded between October and June during 2004/05, 2005/06 and long-term periods in Kazova-Tokat, respectively. Total rainfalls of 506.1, 439.5 and 421.3 mm were recorded between October and June during 2004/05, 2005/06 and long-term periods in Suluova-Amasya, respectively.

Five grasspea lines (38, 439, 452, 455 and 463) were obtained from the International Center for Agricultural Research in the Dry Areas (ICARDA). Seeds were sown on the 1st of November and the 27th of October in 2004 and 2005 in Kazova-Tokat, and on the 4th of November and the 25th of October, 2004 and 2005 in Suluova-Amasya, respectively. Plot size was 5 x 1.8 m, and sowing rate was 80 kg.ha^{-1} 30 kg. N ha^{-1} and 80 kg. P_2O_5 ha^{-1} were uniformly applied to the soil prior to sowing. Seeds were harvested at maturity. ADF and NDF in seeds were determined according to Soest et al. (1991). The crude fat content was determined by using Soxhlet method (AOAC, 1984). Nitrogen content in seeds was determined by the Kjeldahl procedure described by Nelson and Sommers (1980) and crude protein content was calculated multiplying the total nitrogen content values by 6.25. During 2004-05, grasspea seeds were analyzed for contents of amino acids by using Phenomenex EZ Faast GC-FID Hydrolized Amino Acid Analysis Kit (Anonymous, 1998). Analysis of variance and LSD analysis for mean comparisons were conducted as outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Seed yield

Seed yield was influenced by both locations and lines. Locations x line interaction were also statistically significant (Table 1). Two years averaged results indicated that line 439 produced the highest seed yield (1583 kg.ha^{-1}), whereas the line 463 had the lowest seed yield (1079 kg.ha^{-1}). Averaged seed yields were obtained as 1611 and 965 kg.ha^{-1} in Kazova-Tokat and Suluova-Amasya, respectively. Milczak et al. (2001), Sarkar et al. (2003) and Montenegro and Mera (2009) obtained lower seed yields than those in this study, but similar results were reported by Karadag and Buyukburc (2004a), Karadag and Buyukburc (2004b) and Karadag and Iptas (2007); whereas, Abd El-Moneim and Cocks (1993) obtained higher seed yields than those reported in this study.

The different ecological conditions (precipitation and temperature) in the two locations and different cultivars could cause location x line interactions. El-Moneim and Cocks (1993) stated that seed yields of *Lathyrus* species

Table 2. Amino acid contents of grasspea lines grown in Kazova-Tokat and Suluova Amasya in the growing season of 2004-05.

Locations	Kazova-Tokat					Suluova-Amasya				
Lines	452	439	455	463	38	452	439	455	463	38
CP %	22.89	25.96	26.21	24.70	28.64	27.34	25.07	26.13	23.69	26.23
Alanine (Ala)	0.99	1.03	0.98	1.01	1.35	0.97	1.02	1.06	1.17	1.08
Glycine (Gly)	0.91	0.96	0.90	0.94	1.21	0.89	0.96	0.99	1.03	0.91
*Valine (Val)	1.08	1.15	1.12	1.23	1.63	1.13	1.15	1.15	1.31	1.17
*Leucine (Leu)	1.71	1.76	2.05	2.08	2.32	1.73	1.84	1.82	1.88	1.80
*Isoleucine (Ile)	1.00	1.11	1.15	1.28	1.58	0.98	1.05	1.06	1.22	1.13
*Threonine (Thr)	0.84	0.88	0.90	0.88	1.26	0.79	0.86	0.91	0.88	0.83
Serine (Ser)	1.09	1.16	1.41	1.26	1.59	0.93	1.05	1.18	1.18	1.08
Proline (Pro)	1.06	1.14	1.23	1.30	1.57	1.06	1.09	1.17	1.24	1.13
Aspartic acid (Asp)	2.74	2.94	4.68	7.62	5.06	3.74	3.10	2.95	4.85	4.64
*Methionine (Met)	0.18	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00
Proline (Pro)	0.11	0.10	0.13	0.41	0.34	0.00	0.00	0.10	0.40	0.42
Glutamic acid (Glu)	3.45	3.53	3.48	3.48	4.76	3.15	3.46	3.15	0.40	3.84
*Phenylalanine (Phe)	1.06	1.05	1.26	1.26	1.44	1.04	1.12	1.10	1.17	1.10
*Lysine (Lys)	1.16	1.10	1.66	1.83	1.93	1.46	1.46	1.34	1.64	1.64
*Histidine (His)	0.00	0.00	0.64	0.86	0.00	0.80	1.06	0.84	0.00	0.92
Tyrosine (Tyr)	0.70	0.70	0.75	0.82	1.00	0.76	0.81	0.79	0.82	0.79

* Essential amino acids, CP: crude protein

were linearly related to total rainfall in similar ecological conditions. In Suluova-Amasya location, the low seed production was probably related to the delayed appearance of floral buds, corresponding with the onset of drought periods (low precipitation) in spring, particularly in May, causing high abortion rates in flowering and young pods after fertilization. Barnes et al. (2003) reported that the critical period of forage legumes for water requirement starts from the beginning of flowering to seed formation. Yield may not increase even if the water requirement is met after this critical period.

CP

The crude protein contents significantly changed among lines, and location x line interaction was also statistically significant (Table 1). There were no statistically significant differences between locations in this character. The highest and the lowest crude protein contents (28.64 and 22.89%) in Kazova-Tokat location were obtained from the lines 38 and 452, respectively. In Suluova-Amasya location, the highest crude protein content (27.34%) was obtained from the line 452 and the lowest one (23.69 %) from the line 463. The crude protein content average over locations was 27.44% for line 38 and 24.19% for line 463. While similar CP values were reported by Kiehn and Reimer (1992) and Hadjipanayiotou and Economides (2001), our CP values were lower than those reported by Granati et al. (2001) and Milczak et al. (2001). Different cultivars have different growth and CP productions and soil nitrogen level also affected the plant CP values.

Amino acids (aa)

Amino acid contents of grasspea lines are shown in Table 2. Amino acid contents seemed reasonable for animal production, especially for the seven essential amino acids. Methionine amino acid was not found at the graspea lines, except line 452. Aspartic acid and glutamic acid percentages were higher than those of the other amino acids. The highest aspartic acid content was obtained (7.62%) from line 463 at Kazova-Tokat location. Hadjipanayiotou and Economides (2001) reported similar amino acid contents, but our results were lower than the findings of Milczak et al. (2001). The animal feed industry uses soybean to meet the animal requirement of CP and essential amino acids. However, soybean is quite expensive for the feed industry as compared to grasspea. Grasspea seeds have potential to supply enough CP and amino acid requirements of monogastric animals, except methionine. Since grasspea can be grown in wide range of environmental conditions, grasspea production should be increased to replace soybean meal as a source of protein to lower the cost of animal feeds (Hanbury et al.,

Table 3. Two-years averaged values of acid detergent fiber and neutral detergent fiber contents of grasspea lines grown in Kazova-Tokat and Suluova-Amasya during 2004/05 and 2005/06.

	Acid detergent fiber content (%)			Neutral detergent fiber content (%)		
Lines	**Kazova-Tokat**	**Suluova-Amasya**	**Mean**	**Kazova-Tokat**	**Suluova-Amasya**	**Mean**
452	4.00 de[1]	9.72 a	6.86 a	10.96 bcd[1]	13.71 ab	12.34 ab
439	5.65 bcd	9.05 a	7.35 a	10.90 bcd	11.40 bc	11.15 b
455	3.03 e	9.55 a	6.29 ab	8.17 d	12.19 b	10.18 b
463	3.87 de	6.61 bc	5.24 b	8.33 cd	15.51 a	11.92 ab
38	4.78 cde	7.94 ab	6.36 ab	13.80 ab	13.30 ab	13.55 a
Mean	4.26 b[2]	8.57 a	6.42	10.43 b[2]	13.22 a	11.83
LSD_{Lo}	1.04**			1.42**		
LSD_{Ln}	1.22*			2.25**		
LSD_{LoxLn}	2.32**			3.18**		

Lo: Location; Ln: line; LoxLn: line x location interaction; * significant at $P < 0.05$; ** significant at $P < 0.01$; ns: not significant.
[1] Means of different Line-location combinations with the same letter are not statistically significant according to the LSD test at $P<0.05$;
[2] means of locations with the same letter are not statistically significant at $P < 0.05$.

2000).

ADF

There were statistically significant differences between locations, lines and different location-line combinations in ADF (Table 3). Different ecological conditions, such as precipitation and temperature, in the locations as well as the differences in cultivars could cause such differences. Two years averaged results indicated that the line 439 produced the highest ADF content (7.35%), whereas the line 463 had the lowest content (5.24%). Average ADF contents were obtained as 4.26 and 8.57% in Kazova-Tokat and Suluova-Amasya, respectively. This variation may be attributed to climatic differences, particularly to a higher air temperature during the June and July in Kazova-Tokat compared to those in Suluova-Amasya location. Hadjipanayiotou and Economides (2001) reported similar ADF levels, but Hanbury et al. (2000) and Gonzales and Andres (2003) reported higher ADF values than our results. Since ADF values have negative correlation with ruminant digestions (Soest, 1994), lower values of ADF are preferable for animal production.

NDF

NDF content was statistically significant influenced by locations and lines (Table 3). Location x line interaction was also statistically significant. Ecological conditions, such as precipitation and temperature, as well as the cultivars used could cause such differences. In Kazova-Tokat location, the highest and the lowest NDF contents were obtained as 13.80 and 8.17% from the lines 38 and 455, respectively. In Suluova-Amasya location, the highest and the lowest NDF contents varied from 15.51 to 11.40% for line 463 and 439, respectively. Grasspea lines grown in Suluova-Amasya locations had higher NDF values than in Kazova-Tokat. This is probably due to higher air temperatures recorded during June and July in Suluova-Amasya location. Hadjipanayiotou and Economides (2001) reported similar NDF levels, but Hanbury et al. (2000) and Gonzales and Andres (2003) reported higher NDF values than our results. NDF value should be lower for monogastric and ruminant animals. Ruminant animals may require certain level of NDF values to have normal rumination, but higher NDF values could lower the animal intake (Soest, 1994).

Crude fat (CF)

There were statistically significant differences among the lines in crude fat content, and location x line interaction was also statistically significant (Table 4). There were no significant differences between locations. The highest crude fat content (5.30%) was obtained from the line 439 while the lowest one (3.72%) was obtained from the line 455 in Kazova-Tokat location. In Suluova-Amasya location, the highest and the lowest crude fat contents (5.45 and 2.63%) were obtained from lines 463 and 38, respectively. According to the two years averages, the lowest crude fat content (3.22%) was obtained from the line 38 and the highest one (5.07%) from line 463. Our results were higher than the findings of Milczak et al. (2001). Ecological conditions and the differences in cultivars might cause these differences. In the feed, fat content usually added energy sources, but high fat content is known to interrupt digestions of ruminants (Soest,

Table 4. Two-years averaged values of crude fat content of grasspea lines grown in Kazova-Tokat and Suluova-Amasya during 2004/05 and 2005/06.

Lines	Crude fat content (%)		
	Kazova-Tokat	Suluova-Amasya	Mean
452	4.79 ab[1]	4.40 abc	4.59 ab
439	5.30 a	3.90 bc	4.60 ab
455	3.72 bcd	3.43 cd	3.58 bc
463	4.68 ab	5.45 a	5.07 a
38	3.81 bcd	2.63 d	3.22 c
Mean	4.46	3.96	4.21
LSD_{Lo}	ns		
LSD_{Ln}	1.13**		
LSD_{LoxLn}	1.19*		

Lo: Location; Ln: line; LoxLn: line x location interaction; * significant at P < 0.05; ** significant at P < 0.01; ns: not significant. [1] Means of different Line-location combinations with the same letter are not statistically significant according to the LSD test at P<0.05; [2] means of locations with the same letter are not statistically significant at P < 0.05.

1994). Fat contents of seeds (soybean, sunflower, etc.) need to be lowered before being used as animal feeds (Church and Pond, 1988). Since grasspea has a natural low fat content, this could be an advantage when used in animal production.

Annual rainfall and its distribution significantly affected the seed yield and chemical composition of grasspea seeds grown in semi-arid regions of Turkey. 439 and 38 grasspea lines were potentially promising lines as the animal fodder due to high nutritional value of their seeds, their high seed yield, great tolerance to drought and water logging conditions.

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