MEDWELL PUBLISHING
Journal of Animal and Veterinary Advances 8 (7): 1337-1342, 2009
ISSN: 1680-5593

Evaluation of Annual Legumes and Barley as Sole Crops and Intercrop in Spring Frost Conditions for Animal Feeding I. Yield and Quality

[1]Halil Yolcu, [2]Mahmut Dasci and [2]Mustafa Tan
[1]Kelkit Aydin Dogan Vocational Training School, Gumushane University,
29600, Kelkit, Gumushane, Turkey
[2]Department of Field Crops, Faculty of Agriculture,
Ataturk University, 25240, Erzurum, Turkey

Abstract: This study evaluated sole grass pea (*Lathyrus sativus* L.), sole common vetch (*Vicia sativa* L.), sole barley (*Hordeum vulgare* L.), common vetch + barley intercrop, common vetch (I) and barley (I) in terms of yields and quality properties in 2006-2007 at Kelkit Aydin Dogan Vocational Training School Research Station of Gumushane University, Turkey. Intercrop plants were separated as common vetch (called as common vetch I) and barley (called as barley I). Plants were seeded in April of both years in a randomized complete block design with 3 replications. The study plots were 3.0 m long by 1.68 m wide, with 24 cm row spacing. Each plot was fertilized with 20 ton ha^{-1} organic farmyard manure. The year effects were significant in dry matter yield, crude protein, crude protein yield, acid detergent fiber and neutral detergent fiber. The legumes especially were injured by frost in 2007. Significant differences were found in terms of Dry Matter Yield (DMY), Crude Protein (CP), Crude Protein Yield (CPY), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), Dry Matter Intake (DMI), Dry Digestible Matter (DDM) and Relative Feed Value (RFV) amongst all the plants. Sole common vetch and sole barley had good properties in DMY, CP and CPY. Sole grass pea, common vetch (I), sole common vetch and intercrops showed good quality properties in ADF and NDF. Sole grass pea especially, sole common vetch and common vetch (I) had good quality properties in DMI, DDM and RFV. Farmers should prefer sole common vetch and sole grass pea cultivation in yield and quality and regulate their seeding times according to days with frost in similiar conditions.

Key words: Common vetch, grass pea, barley, intercrop, crude protein, acid detergent fiber

INTRODUCTION

Grass pea (*Lathyrus sativus* L.) can be cultivated for dry hay yield, seed production and different intentions (Acikgoz, 2001). It is a potentially valuable feed and food crop in semi-arid regions (Yang *et al*., 2004). It has a good yield potential and very tasty seeds with high content of protein (up to 30%) and lysine (Rybinski *et al*., 2006). Vetches are good forage crops because of superior yields and quality and many of vetches are nutritive because of thin stems and plentiful leaves (Serin and Tan, 2001). Common vetch is one of the most cultivated forage crops in Turkey (Acikgoz, 2001).

Cereals are widespread cultivated as roughage in many countries for animal feeding. They are important contributors to animal feeding in Turkey, both as grain and forage (Tuna and Orak, 2007). Forage quality of cereal hay is usually lower than that required to meet satisfactory production levels for many categories of livestock (Lithourgidis *et al*., 2006). Common vetch (*Vicia sativa* L.) an annual legume with climbing growth habit and high levels of protein, is usually grown in mixtures with small grain cereals for hay or forage production (Lithourgidis *et al*., 2006). Common vetch is cultivated together with cereals as intercropping in many regions of the world.

Especially, forage crop field areas are very low amongst all agricultural fields because farmers mostly cultivate cereals and industry plants in some parts of East Mediterranean environments. Rangelands are also mostly devastated due to excessive grazing. There is often an acute shortage of livestock feed in Mediterranean environments and animals are frequently fed much less than their requirement to achieve reasonable productivity (Qamar *et al*., 1999). Recently, forage crops cultivation has increased as a result government support in Turkey

Corresponding Author: Halil Yolcu, Kelkit Aydin Dogan Vocational Training School, Gumushane University, 29600, Kelkit, Gumushane, Turkey

(Yolcu and Tan, 2008). Since annual forage crops stay shorter in fields when compared to perennial forage crops, farmers generally prefer annual forage crops cultivation except lucerne. Besides annual forage crop cultivation also become widespread in organic animal production regions.

Common vetch is less cold-hardy (Miller and Hoveland, 1995). Spring frosts have negative effect on seedling of common vetch especially and grass pea and they may decrease in yield and quality of annual forage crop production. There are general information in farmers about yield of annual forage crops and their intercrops. But we have no adequate information of yield and quality properties (CP, CPY, ADF, NDF, DMI, DDM and RFV) of annual forage crops and their intercrops in organic manure and spring frost conditions.

Therefore, the aims of this study were to evaluate performances of sole common vetch, sole grass pea and sole barley, intercrops (common vetch + barley), common vetch (I) and barley (I) in terms of yield and quality properties in organic manure and spring frost conditions for animal feeding.

MATERIALS AND METHODS

The experiment was conducted at research fields of Kelkit Aydin Dogan Vocational Training School of Gumushane University at an altitude 1400 m above sea level in the north east part (40°08'N, 39°25'E) of the Turkey in 2006 and 2007.

The experiment was arranged in a randomized complete block design with 3 replications. The study plots were 3.0 m long by 1.68 m wide, with 24 cm row spacing. The experimental plot was each $1.68 \times 3 = 5.04$ m^2 in size. Sole common vetch, sole grass pea, sole barley and common vetch + barley intercrops were seeded in April of 2006 and 2007 years. The intercrop was seeded in cross seeding pattern. The crops were sown at seeding rates of 90 and 50 kg ha^{-1} for common vetch and barley intercrops, respectively (Serin and Tan, 2001), 100 kg ha^{-1} for sole grass pea (Acikgoz, 2001), 100 kg ha^{-1} for sole common vetch (Acikgoz, 2001) and 500-600 plants m^{-2} for sole barley (Kun, 1996).

Each of the experiment plots were fertilized with 20 ton ha^{-1} organic farmyard manure before seeding in each year. The used farmyard manure had 7.74 and 7.45 pH, 19.7 and 18.5% dry matter, 20.00 and 21.60 organic matter, 2500 and 2700 ppm N, 2100 and 1800 ppm P and 1200 and 1200 ppm K in 2006 and 2007, respectively. The plants were irrigated twice with intervals of 15 days after precipitation in each growing season (Serin and Tan, 2001).

Generally, climatic properties of the experiment location in Kelkit were characterized by low humidity, dry summers and snowy winters. Data of experiment years and long terms averages are shown in Table 1. Numbers of days with frost in April were 2 days in 2006 and 7 days in 2007. The crops especially sustained an injury from frost in 2007. The experiment area soils were slightly alkaline, poor-middle level in organic matter. The soils

Table 1: Climatic dates of the research location in 2006, 2007 years and long-term average (1975-2006) at the location

	Total precipitation (mm)			Main air temperature (°C)			Mean relative humidity (%)		
Months	2006	2007	LTM*	2006	2007	LTM	2006	2007	LTM**
January	30.8	53.0	11.4	-3.1	-1.9	-1.8	72.6	69.5	1.3
February	45.1	25.3	11.5	0.6	-0.2	-0.9	70.5	66.1	3.7
March	77.3	52.0	13.3	5.8	3.6	3.2	66.7	69.6	5.1
April	108.3	35.1	13.7	9.7	5.4	9.5	69.6	68.2	6.2
May	85.4	40.7	15.9	13.6	17.3	13.4	69.3	59.0	7.4
June	24.2	32.2	10.5	19.4	18.2	16.9	67.2	65.8	9.3
July	20.4	1.1	4.4	18.7	21.6	20.1	72.8	57.6	10.1
August	0.7	31.4	3.8	24.2	21.6	19.9	58.0	64.6	10.0
September	23.5	1.2	5.5	16.2	18.6	16.5	69.2	60.1	8.1
October	70.9	54.3	9.6	12.3	12.9	11.2	73.8	69.2	5.6
November	87.4	98.6	10.1	3.9	3.7	4.9	72.7	74.3	2.1
December	12.8	69.0	11.9	-2.5	-0.8	0.4	70.7	77.4	0.8
Total/mean	586.8	493.9	10.1	9.9	10.0	9.4	69.4	66.8	5.8

LTM: Long Term Means, LTM*: Numbers of mean rainy and snowy day, LTM**: Period of mean bringing light (hours)

Table 2: Some physical and chemical properties of soils in research area

Soil depth (cm)	Tekstur class	pH	Lime ($CaCO_3$ %)	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	Organic matter (%)
0-30	Clay-loamy	7.57	37.95	53.0	421.0	1.74
30-60	Clay-loamy	7.70	15.52	22.0	456.0	1.25
Mean		7.64	26.74	37.5	438.5	1.50

were at a middle level in available P and rich in K. Some chemical and physical properties of the soils in the experiment area are shown in Table 2. The study was conducted at another part of the same field which had similar properties in 2007.

Sole crops barley (Tan and Serin, 1997) and intercrops (Serin and Tan, 2001) were harvested in milk stage of barley and sole grass pea was harvested in all flowering stage (Serin and Tan, 2001). Sole common vetch was harvested in stuffed stage of few pods near the soil (Acikgoz, 2001). The intercrops and sole crops collected by harvesting 1 meter squared areas from each plot and intercrop plants were separated as common vetch (called as common vetch I) and barley (called as barley I).

After each sample was oven-dried at 68°C for 48 h, they ground to pass 1 mm. The Kjeldahl method (Bremner, 1996) and a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Konigswinter, Germany) were used to determine total N of all the plants. CP content of all the plants was calculated by multiplying N contents by a coefficient of 6.25 (Frank, 1975). ADF and NDF analyses were determined by Van Soest (1963). DDM, DMI and RFV were calculated according to the following equations adapted from common formulas for forages (Schroeder, 1994).

$$DDM\% = 88.9 - (0.779 \times ADF\%),\ DMI\% = 120/NDF$$
$$RFV = (DDM \times DMI\%)/1.29$$

Crude protein, CPY, ADF, NDF, DDM, DMI and RFV contents of intercrop were calculated as weighted mean squares by taking botanical composition into consideration.

Statistical analysis: Data were analyzed using JMP procedure (SAS Institude, 2002) and means were compared with LSD test method.

RESULTS AND DISCUSSION

In this region, during the spring there are late frosts and they gives a negative effect to the forage crop production. In the 2nd year of this study especially legumes sustained an injury from spring latest frosts and total precipitation of the 2nd year was also lower than those of the 1st year. Thus, there were significant differences ($p<0.01$) in dry matter yields between the years. First year mean dry matter yields were greater than those of 2nd year.

All the plants (sole grass pea, sole common vetch, sole barley, intercrop and common vetch (I) and barley (I)) showed important differences in terms of dry matter yields in both years (Table 3). The highest dry matter yields found in sole common vetch, sole grass pea and sole barley in the 1st year. These values were 2899.7, 2887.0 and 2733.0 kg ha^{-1}, respectively. The highest dry matter yield was determined in only sole barley (3271.8 kg ha^{-1}) because legumes were injured by spring latest frost in the 2nd year. Intercrops, barley (I), sole grass pea, sole common vetch and common vetch (I) had 2361.2, 2161.6, 1166.1, 367.9 and 199.7 kg ha^{-1} dry matter yields in the 2nd year, respectively. Similarly, differences in dry matter yields have been shown by Al-Masri (1998) amongst pure vetch, pure barley, mixture, vetch from mixture and barley from mixture, by Qamar *et al.* (1999) amongst sole barley, sole vetch and mixtures, by Ross *et al.* (2004) amongst berseem clover sole crop and intercrops and by Lithourgidis *et al.* (2007) amongst sole common vetch, sole barley, sole winter wheat, common vetch + barley intercrop and common vetch + winter wheat.

The year effects were significant ($p<0.01$) in crude protein content and crude protein yield (Table 3). Second year had more crude protein content than those of 1st year. Crude protein yield in the 1st year was higher than those of 2nd year. This result arose from harmful effect of frost to dry matter yields in the 2nd year. Differences of crude protein contents amongst sole common vetch, sole grass pea, intercrop, common vetch (I), barley (I) were found to be significant ($p<0.01$) in the 1st and 2nd years. The highest crude protein content was determined in the sole common vetch (13.29 g/100 g) in the 1st year. This plant was followed by sole barley, common vetch (I), intercrops, barley (I) and sole grass pea (Table 3). In the 2nd year, the highest crude protein contents were gained in common vetch (I) (14.08 g/100 g), sole common vetch (14.04 g/100 g) and sole barley (13.69 g/100 g). Crude protein variations were showed in other studies done by Assefa and Ledin (2001) in monoculture oat, monoculture vetch and mixture, by Ross *et al.* (2004) in berseem clover sole crop and intercrops and by Lauriault and Kirksey (2004) in monoculture of wheat, triticale and oat and in intercrops of these cereals with hair vetch and winter pea. Crude protein yields of sole grass pea, sole common vetch, intercrop, common vetch (I), barley (I) were significantly different ($p<0.01$) in the 1st and 2nd year results. Sole common vetch had higher crude protein yield (385.18 kg ha^{-1}) than the others in the 1st year. But in the 2nd year, sole barley had the highest crude protein yields (447.04 kg ha^{-1}). This plant was followed by intercrop (255.73 kg ha^{-1}) and barley I (247.61 kg ha^{-1}). Strydhorst *et al.* (2008) noted that there were differences in crude protein yield amongst faba bean-barley, lupin-barley, pea-barley intercrops and sole barley.

Table 3: Dry matter yield, crude protein content and crude protein yield of sole grass pea, common vetch, barley, intercrops, common vetch (I) and barley (I)

	Dry matter yield (kg ha^{-1})		Crude protein (%)		Crude protein yield (kg ha^{-1})	
Plants	2006	2007	2006	2007	2006	2007
Common vetch (I)	1143.7B	199.7D	12.44AB	14.08A	143.320C	28.110D
Barley (I)	456.7C	2161.6B	12.020B	11.46B	54.760D	247.610B
Intercrops	1600.3B	2361.2B	12.310B	11.68B	198.080C	255.730B
Sole common vetch	2899.7A	367.9D	13.290A	14.04A	385.180A	51.60CD
Sole barley	2733.0A	3271.8A	12.77AB	13.69A	348.95AB	447.040A
Sole grass pea	2887.0A	1166.1C	10.920C	11.33B	315.310B	132.040C
Mean	1953.4A	1588.0B	12.290B	12.71A	240.930A	197.020B
LSD plant	52.95	68.98	0.93	0.56	68.30	84.990
LSD year	23.77	-	0.30	-	29.81	-
LSD p×y	58.24	-	0.73	-	73.03	-

Capital letters within the same column are significantly different at 1%

Table 4: Acid detergent fiber and neutral detergent fiber of sole grass pea, common vetch, barley, intercrops, common vetch (I) and barley (I)

	Acid detergent fiber (%)		Neutral detergent fiber (%)	
Plants	2006	2007	2006	2007
Common vetch (I)	29.56BC	31.83B	41.75C	45.97C
Barley (I)	32.13B	30.44B	56.74A	55.73B
Intercrops	30.28BC	30.56B	45.96B	54.88B
Sole common vetch	36.40A	30.13B	38.37CD	44.74C
Sole barley	38.33A	34.75A	56.64A	59.06A
Sole grass pea	28.87C	30.18B	35.56D	38.25D
Mean	32.60a	31.31b	45.84B	49.77A
LSD plant	3.04	2.36	3.39	2.93
LSD year	1.05	-	1.23	-
LSD p×y	2.58	-	3.00	-

The small letters within the same line are significantly different at 5%, capital letters within the same column and line are significantly different at 1%

Acid detergent fiber ($p<0.05$) and neutral detergent fiber ($p<0.01$) contents of all the plants were different between years (Table 4). Sole grass pea, sole common vetch, intercrop, common vetch (I) and barley (I) revealed significant differences in terms of acid detergent fiber and neutral detergent fiber in the both years. The lowest acid detergent fiber content was determined as 28.87 g/100 g in sole grass pea in the 1st year. Also, the subsequent plants to sole grass pea were common vetch (I) (29.56 g/100 g) and intercrop (30.28 g/100 g). There were important differences in acid detergent fiber in the 2nd year. Acid detergent fiber of sole barley had the highest ADF content amongst all the plants. Also, statistically other all the plants were similar. Neutral detergent fiber contents were importantly different for all the plants in both years. The lowest neutral detergent fiber content was found in sole grass pea (35.56 g/100 g) in the 1st year (Table 4). This plant was followed by sole common vetch (38.37 g/100 g) and common vetch (I) (41.75 g/100 g). Similarly, sole grass pea had the lowest neutral detergent fiber content (38.25 g/100 g) in the 2nd year. Subsequent to sole grass pea, sole common vetch and common vetch (I) had 44.74 and 45.97 g/100 g neutral detergent fiber content, respectively. Similar, differences between plant groups have also been displayed in ADF and NDF by Ross *et al.* (2004), in NDF by Lauriault and Kirksey (2004) in ADF and NDF by Lithourgidis *et al.* (2006).

All the plants showed significant differences in dry matter intake in the 1st ($p<0.01$), 2nd year ($p<0.05$) and the means of 2 years ($p<0.01$). The highest dry matter intakes were found in sole grass pea (3.37%), sole common vetch (3.13%) and common vetch (I) (2.87%) in the 1st year, respectively (Table 5). Sole grass pea also had the highest dry matter intake in the 2nd year. In the means of 2 years, sole grass pea (3.25%), sole common vetch (2.89%) and common vetch (I) (2.74%) had higher dry matter intake than the others. Dry digestible matter contents were significantly different amongst all the plants in the 1st year and the means of 2 years but no in the 2nd year. Sole grass pea, common vetch (I) and intercrops produced the highest dry digestible matter content in the 1st year, respectively. These values were 66.41, 65.87 and 65.31%, respectively. Also, in the means of 2 years, sole grass pea (65.90%), intercrops (65.20%) and common vetch (I) (64.99%) had the highest dry digestible matter contents. Relative feed value displayed significant differences ($p<0.01$) amongst all plants in the 1st year, 2nd year and the means of 2 years. In the 1st year and the means of 2 years, the highest relative feed values were found in sole grass pea (173.72, 159.03 and 166.11) (Table 5). In the means of 2 years, this plant was followed by sole common vetch (141.01) and common vetch (I) (137.83), respectively. Similar variation in RFV amongst monocultures of common vetch, oat, triticale and mixtures of common vetch with each of the cereals were also reported by Lithourgidis *et al.* (2006).

The results showed that sole common vetch and sole barley had good potential in terms of dry matter yield, crude protein and crude protein yield. But yields of common vetches decreased by frost damage in the 2nd year. Also in terms of ADF and NDF, sole grass pea, common vetch (I), sole common vetch and intercrops had

Table 5: Dry matter intake, dry digestible matter and relative feed value of sole grass pea, common vetch, barley, intercrops, common vetch (I) and barley (I)

	Dry matter intake (%)			Dry digestible matter (%)			Relative feed value		
Plants	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean
Common Vetch (I)	2.87C	2.61b	2.74BC	65.87AB	64.10	64.99A	146.77B	129.71B	137.83BC
Barley (I)	2.11E	2.15b	2.13D	63.87B	65.19	64.53AB	104.72D	108.82B	106.75DE
Intercrops	2.61D	2.19b	2.38CD	65.31AB	65.10	65.20A	132.20C	110.35B	120.30CD
Sole common vetch	3.13B	2.68b	2.89B	60.54C	65.43	62.99B	146.80B	136.05B	141.01B
Sole barley	2.12E	2.03b	2.07D	59.04C	61.83	60.43C	96.96D	97.38B	97.17E
Sole grass pea	3.37A	3.14a	3.25A	66.41A	65.39	65.90A	173.72A	159.03A	166.11A
Mean	2.62	2.41	2.51	63.51	64.51	64.01	128.89	120.57	124.56
LSD plant	0.22	1.01	0.49	2.37	-	1.93	9.77	40.06	19.93
LSD year	-	-	-	-	-	-	-	-	-
LSD p×y	-	-	-	-	-	2.72	-	-	-

The small letters within the same column or line are significantly different at 5%, capital letters within the same column or line are significantly different at 1%

good quality properties. Sole grass pea especially, sole common vetch and common vetch (I) showed good performance in DMI, DDM and RFV. Overall, farmers should prefer sole common vetch and sole grass pea cultivation in terms of yield and quality under similiar conditions. But the farmers should regulate their seeding periods according to days with frost. These results may guide farmers who cultivate these forage crops under organic farmyard manure conditions and who use forages without making quality analysis for animal feeding.

REFERENCES

Acikgoz, E., 2001. Forage Crops. University of Uludag, Uludas University, Bursa, Turkey Publication No: 182, Bursa, pp: 1-584 (in Turkish). ISBN: 975-564-124-6.

Al-Masri, M.R., 1998. Yield and nutritive value of vetch (*Vicia sativa*)-barley (*Hordeum vulgare*) forage under different harvesting regimens. Trop. Grasslands, 32: 201-206. http://www.tropicalgrasslands.asn.au/Tropical%20Grasslands%20Journal%20archive/PDFs/Vol_32_1998/Vol_32_03_98_pp201_206.pdf.

Assefa, G. and I. Ledin, 2001. Effect of variety, soil type and fertilizer on the establishment, growth, forage yield quality and voluntary intake by cattle of oats and vetches cultivated in pure stands and mixtures. Anim. Feed Sci. Technol., 92: 95-111. DOI: 10.1016/S0377-8401(01)00242-5. PubMed Accession No.: IDS No.: 451CW. http://apps.isiknowledge.com/full_record.do?product=WOS&search_mode=GeneralSearch&qid=1&SID=Q2B8oaCh73aAa@593fm&page=1&doc=4.

Bremner, J.M., 1996. Nitrogen-Total. 2nd Edn. Methods of Soil Analysis Part II. Chemical and Microbiological Methods. Agronomy. No: 9, Madison, Wisconsin, USA, pp: 129-134.

Frank, A.L., 1975. Basic Food Chemistry. The Avi Publishing Company Inc., Wesport.

Kun, E., 1996. Cereals I. University of Ankara, Publication No: 1451, Ankara. Ankara University, Ankara Turkey, Publication No.: 1451. ISBN: 975-482-345-6.

Lauriault, L.M. and R.E. Kirksey, 2004. Yield and nutritive value of irrigated winter cereal forage grass-legume intercrops in the southern high plains, USA. Agron. J., 96: 352-358. DOI: IDS No.: 805RA http://apps.isiknowledge.com/full_record.do?product=WOS&search_mode=GeneralSearch&qid=3&SID=Q2B8oaCh73aAa@593fm&page=8&doc=364.

Lithourgidis, A.S., I.B. Vasilakoglou, K.V. Dhima, C.A. Dordas and M.D. Yiakoulaki, 2006. Forage yield and quality of common vetch mixtures with oat and triticale in 2 seeding ratios. Field Crop Res., 99: 106-113. DOI: 10.1016/j.fcr.2006.03.008. IDS No.: 084VN. http://apps.isiknowledge.com/full_record.do?product=WOS&search_mode=GeneralSearch&qid=5&SID=Q2B8oaCh73aAa@593fm&page=1&doc=2.

Lithourgidis, A.S., K.V. Dhima, I.B. Vasilakoglou, C.A. Dordas and M.D. Yiakoulaki, 2007. Sustainable production of barley and wheat by intercropping common vetch. Agron. Sustain Dev., 27: 95-99. DOI: 10.1051/agro:2006033. IDS No. 167SY. http://apps.isiknowledge.com/full_record.do?product=WOS&search_mode=GeneralSearch&qid=7&SID=Q2B8oaCh73aAa@593fm&page=1&doc=1.

Miller, D.A. and C.S. Hoveland, 1995. Other Temperate Legumes. In: Barnes, R.F., D.A. Miller and C.J. Nelson (Eds.). Forages, Vol. 1: An Introduction to Grassland Agriculture, pp: 1-516. ISBN: 0-8138-0681-X.

Qamar, I.A., J.D.H. Keatinge, N. Mohammad, A. Ali and M.A. Khan, 1999. Introduction and management of vetch/barley forage mixtures in the rainfed areas of Pakistan. 1. Forage yield. Aust. J. Agric. Res., 50: 1-9. IDS No.: 159LQ. http://apps.isiknowledge.com/full_record.do?product=WOS&search_mode=GeneralSearch&qid=9&SID=Q2B8oaCh73aAa@593fm&page=1&doc=1.

Ross, S.M., J.R. King, J.T. O'Donovan and D. Spaner, 2004. Forage potential of intercropping berseem clover with barley, oat, or triticale. Agron. J., 96: 1013-1020. IDS No.: 843MV. http://apps.isiknowledge.com/full_record.do?product=WOS&search_mode=GeneralSearch&qid=12&SID=Q2B8oaCh73aAa@593fm&page=10&doc=497.

Rybinski, W., W. Baszczak and J. Fornal, 2006. Seed microstructure and genetic variation of characters in selected grass-pea mutants (*Lathyrus sativus* L.). Int. Agrophys., 20: 317-326. http://cat.inist.fr/?aModele=afficheN&cpsidt=18386319.

SAS Institute, 2002. JMP Statistics. Cary, NC, USA: SAS Institute, Inc., pp: 707.

Serin, Y. and M. Tan, 2001. Forage Legumes. Ataturk University Agriculture Faculty. Publication No: 190, Erzurum, Turkey, pp: 177 (in Turkish).

Strydhorst, S.M., J.R. King, K.J. Lopetinsky and K.N. Harker, 2008. Forage potential of intercropping barley with faba bean, lupin, or field pea. Agron. J. 100: 182-190. DOI: 10.2134/agronj2007.0197. IDS No.: 252XC. http://apps.isiknowledge.com/full_record.do?product=WOS&search_mode=GeneralSearch&qid=17&SID=Q2B8oaCh73aAa@593fm&page=4&doc=153.

Schroeder, J.W., 1994. Interpreting Forage Analysis, North Dakota State University. http://www.ag.ndsu.edu/pubs/plantsci/hay/r1080w.htm.

Tan, M. and Y. Serin, 1997. The nutrition values of small grain cereals as hay. Ataturk University, J. Agric., 28: 130-137 (in Turkish).

Tuna, C. and A. Orak, 2007. The role of intercropping on yield potential of common vetch (*Vicia sativa* L.)/oat (*Avena sativa* L.) cultivated in pure stand and mixtures. J. Agric. Biol. Sci., 2: 14-19. http://www.arpnjournals.com/jabs/research_papers/rp_2007/jabs_0307_44.pdf.

Van Soest, P.J., 1963. Use of detergents in the analysis of fibrous feeds. II. A. rapid method for the determination of fiber and lignin. J. Assoc. Offic. Agric. Chem., 46: 829-835.

Yang, H.M., X.Y. Zhang and G.X. Wang, 2004. Relationships between stomatal character, photosynthetic character and seed chemical composition in grass pea at different water availabilities. J. Agric. Sci., 142: 675-681. DOI: 10.1017/S0021859605004831. IDS No.: 936QR. http://apps.isiknowledge.com/full_record.do?product=WOS&search_mode=GeneralSearch&qid=22&SID=Q2B8oaCh73aAa@593fm&page=1&doc=1.

Yolcu, H. and M. Tan, 2008. General view to Turkey forage crops cultivation. Ankara University, Faculty of Agriculture. J. Agric. Sci., 14: 303-312. http://tarimbilimleri.agri.ankara.edu.tr/2008/111_3/makale15.pdf.