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EFFECTS OF HARVEST TIME ON HAY YIELD AND QUALITY OF DIFFERENT BITTER VETCH (*VICIA ERVILIA* L.) LINES

Mahmut Kaplan*, Sati Uzun and Kagan Kökten[1]

Department of Field Crops, Faculty of Agriculture,
University of Erciyes, Kayseri, Turkey

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ABSTRACT

This study was carried out in Kayseri Province of Turkey in the years 2011 and 2012 for two years to determine the effects of harvest time on hay yield and quality of different bitter vetch genotypes. A total of 16 different bitter vetch (*Vicia ervilia* L.) lines supplied from EMRI, DATAE and ICARDA were used as the plant material of the field experiments. Experiments were carried out in randomized block design with 3 replications. Bitter vetch lines were harvested at flower-set, full-bloom and pod-set periods. Green herbage and hay yields, crude protein (CP), protein yield (PY), crude ash (CA), condensed tannin (CT), acid detergent fiber (ADF) and neutral detergent fiber (NDF) characteristics were investigated. Results revealed increasing ADF-NDF ratios, green herbage and hay yields and decreasing crude protein, crude ash and condensed tannin ratios with the progression of harvest time. Pod-set period was determined as the proper harvest time. The lines VE-16, VE-5, VE-1, VE-2 and VE-6 were considered as primary lines to be used in further breeding research and agricultural activities of the region with regard to hay yield and quality.

Key words: Bitter vetch, Condensed tannin, Harvest time, Hay yield, Protein.

INTRODUCTION

Forage legumes not only supply forage for livestock feeding but also enrich soil organic matter content and leave better soil conditions for subsequent crops (Basbag and Gul, 2005). Bitter vetch is highly resistant against drought and therefore it is widely cultivated in various parts of Anatolia for grain forage (Serin *et al.*, 1997) and fodder. It can be cultivated over wide range of soil and topographical conditions in which several other crops are not able to be economically cultivated. Lime-deficient lands, stony and hilly sites can also be used for bitter vetch cultivation (Ayan *et al.*, 2006).

Harvest time, environmental conditions and agronomical characteristics are the most significant factors affecting the forage quality (Buxton *et al.*, 1985; Kamalak *et al.*, 2005a,b). Digestibility of forage decreases with increasing cellulose and lignin contents due to aging of plants (Van Soest, 1994; Wilson *et al.*, 1991; Morrison, 1980). The ratio of shoots with higher cellulose and lignin contents increases, ratio of leaves and consequently the quality of forage decreases with the progression of growth. There are a few researches carried out about intra-specific variations in production and breeding characteristics such as fodder, kernel and hay quality characteristics. Such studies even are limited with only a few species (Larbi *et al.*, 2011).

Objective of this study is to determine the effects of harvest time on hay yield and quality of bitter vetch lines to be cultivated in semi-arid regions like Central Anatolia and able to be used in further breeding researches.

MATERIALS AND METHODS

Experimental Design: A total of 16 different bitter vetch lines were used as the plant material of the experiments. Initials and origins of lines are given in Table 1. Experiments were conducted during the cropping seasons of the years 2011 and 2012. Plants were sown at the end of April and harvested at different periods in June of both experimental years.

*Corresponding author's e-mail: mahmutk@erciyes.edu.tr
[1]Department of Field Crops, Faculty of Agriculture, University of Bingol, Turkey

TABLE 1: Initials and origins of bitter vetch (*Vicia ervilia* L.) lines used in this study.

Initials	*Full name*	*Origin*	*Initials*	*Full name*	*Origin*
VE-1	IFVE 2799 Sel 2510	ICARDA	VE-9	IFVE-248(103)	DATAE
VE-2	IFVE 2801 Sel 2511	ICARDA	VE-10	IFVE-2698(105)	DATAE
VE-3	IFVE 2804 Sel 2513	ICARDA	VE-11	IFVE-2793(106)	DATAE
VE-4	IFVE 2852 Sel 2517	ICARDA	VE-12	IFVE-2797(107)	DATAE
VE-5	IFVE 2943 Sel 2519	ICARDA	VE-13	IFVE-3977(109)	DATAE
VE-6	IFVE 2849 Sel 2522	ICARDA	VE-14	IFVE-2981(110)	DATAE
VE-7	IFVE 2542 Sel 2563	ICARDA	VE-15	Tetikan	EMRI
VE-8	IFVE 4654 Sel 2644	ICARDA	VE-16	Gisrik	EMRI

ICARDA: *International Center for Agricultural Research in the Dry Areas;* DATAE: *Southeastern Anatolian Research Institute;* EMRI*; Eastern Mediterranean Research Institute*

Together with sowing, 50 kg/ha N and 100 kg/ha P_2O_5 were provided as base fertilizers. Amount of seed per hectare was determined by using thousand-kernel weight. Row spacing was arranged as 30 cm and plot sizes were 8 x 1.8 m. Side rows and 50 m strips at plot heads were discarded as side effects. Each harvest was performed from a plot area of 2 x 1.2 m^2. Plants were harvest at three different periods as of flower-set, full-bloom and pod-set. Harvested plants were dried at 70 °C to get hay yield.

Research site: Soil samples were taken from 0-30 cm and analysis results are given in Table 2. Soil texture of the site is "sandy-loam". Soils of the year 2011 were slightly alkaline, unsaline and calcareous with low available phosphorus and significantly low organic material content. Soils of the year 2012 were highly alkaline, unsaline and calcareous with low available phosphorus and insufficient organic material content (Lindsay and Norwell, 1969; FAO, 1990; TOVEP, 1991).

While the temperatures during the first year of experiments were close to long-term averages, they were higher than long-term average during the second experimental year. Precipitations were significantly low in April of the second year. Precipitation was higher than long-term averages in the first year (Fig 1).

Chemical composition: Dry samples were milled through 1 mm sieve and used for analysis. Crude ash content of samples was determined by burning at 550 °C for 8 hours. Kjeldahl method was used to determine the nitrogen (N) content of dried samples

FIG. 1: Ombro-thermal climate diagram for experimental years and long-term averages

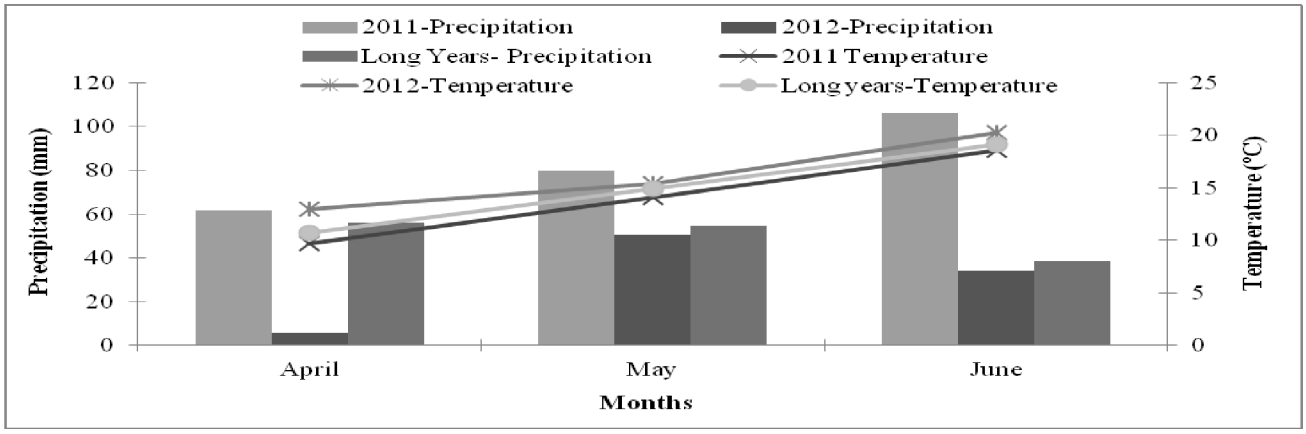


TABLE 2: Physical and chemical characteristics of soils of experimental site.

Years	Texture				pH	Org. Mat.	Lime	K_2O kg/ha	P_2O_5 kg/ha	EC
	% Clay	% Silt	% Sand	Class		%				
2011	10.23	27.14	62.63	Sandy-loam	7.54	0.62	1.09	1123.5	64.2	0.26
2012	9.29	16.97	73.74	Sandy-loam	8.20	1.25	5.48	1268.1	45.1	0.14

taken from the plots. Crude protein was calculated by using the equation of Nx6.25 (AOAC 1990). Tannin was determined in accordance with Makkar *et al.*, (1995); NDF in accordance with Van Soest and Wine (1967) and ADF in accordance with Van Soest (1963) by using ANKOM 200 Fiber Analyzer (ANKOM Technology Corp. Fairport, NY, USA).

Statistical analysis: Variance and correlation analysis on data were performed by using SAS (SAS Inst., 1999) statistical software. Duncan test was used to test the difference between means.

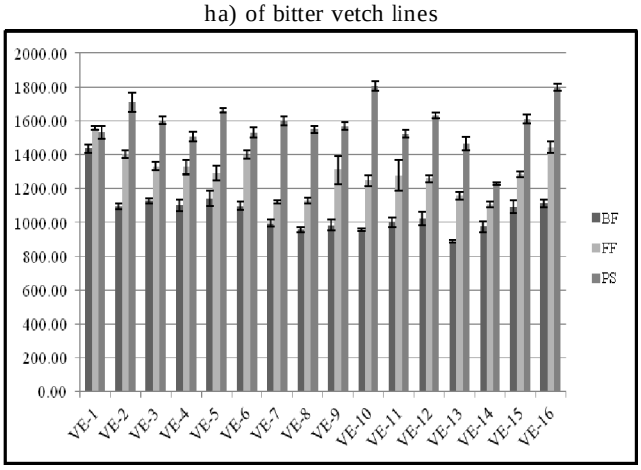
RESULTS AND DISCUSSION

The difference between lines with regard to crude protein, crude ash, ADF and NDF contents were found to be significant at 1% level for harvest time, harvest time x line, genotype x year, harvest time x year, harvest time x line x year interactions. While the harvest time x year interaction was found to be significant at 5% with regard to green herbage yield; the difference between lines was found to be significant at 1% for harvest time, harvest time x line, genotype x year, harvest time x line x year interactions. On the other hand, harvest time x year, harvest time x genotype, genotype x year interactions were found to be insignificant with regard to yield and year was found to be insignificant with regard to protein yield.

Green herbage yields of bitter vetch lines at flower-set period varied between 8877.0-14343.1 kg/ha. While the lowest yield was obtained from VE-13 line, the highest value was observed in VE-1 line. The lowest yield at full-bloom was seen in VE-14 with 11068.6 kg/ha and the highest value was obtained from VE-1 with 12293.9 kg/ha. VE-14 yielded the lowest value with 12293.9 kg/ha at pod-set period and VE-10 yielded the highest value with 18062.1 kg/ha (Fig 2).

With regard to hay yield at flower-set period, VE-7 had the lowest value with 1805.7 kg/ha and VE-3 had the the highest vale with 2802.3 kg/ha. Hay yield of lines at full-bloom varied between 2316.9-3932.6 kg/ha with the lowest in VE-14 and the highest in VE-1. As it was in full-bloom, the lowest yield at pod-set was also seen in VE-14 with 4317.7 kg/ha and the highest yield was obtained from VE-16 with 6054.2 kg/ha (Fig 3).

FIG. 2: Effects of harvest times on green herbage yield (kg/ha) of bitter vetch lines

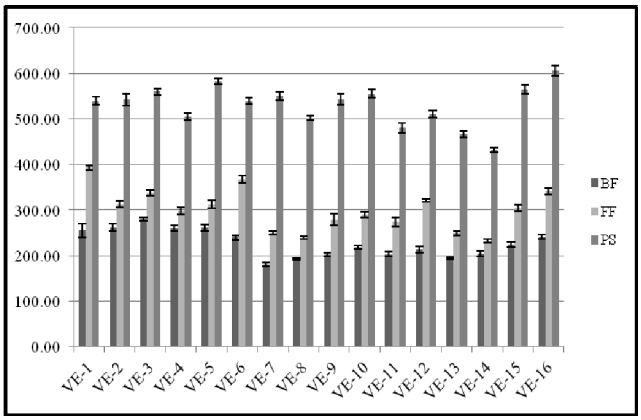


BF: Beginning of Flowering, FF: Full Flowering, PS: Pods of Setting; line, year, harvest time x line, line x year, harvest time x line x year at ≤ 0.01; harvest time x year at $p \leq 0.05$

ADF ratios of bitter vetch lines at flower-set were between 20.41-22.57% with the lowest ratio in VE-14 and the highest in VE-8. While the lowest value at full-bloom was observed in VE-4 with 21.98%, the highest ratio was seen in VE-2 with 24.80%. At pod-set period, VE-8 yielded the lowest ratio with 22.49% and VE-10 yielded the highest ratio with 27.73% (Fig 4).

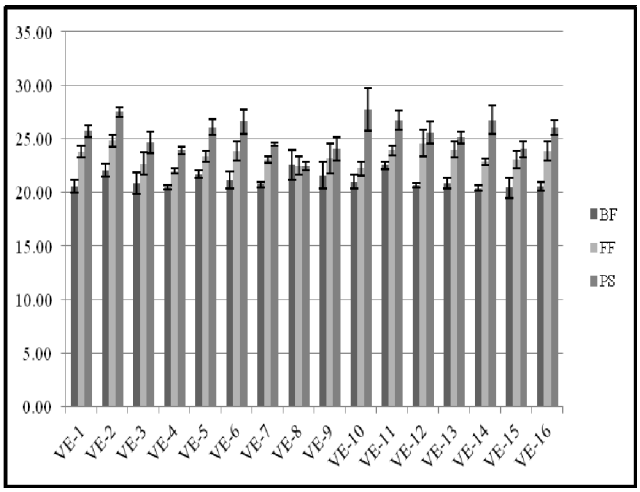
NDF ratios at flower-set varried between 25.10-31.64% with the lowest value in VE-13 and the highest in VE-6. Ratios at full-bloom were found to be between 29.52-34.10% with the lowest in VE-4 and the highest in VE-5. While the lowest ratio at pod-set was obtained from VE-7 with 33.81%, the

FIG. 3: Effects of harvest times on hay yield (kg/ha) of bitter vetch lines



BF: Beginning of Flowering, **FF:** Full Flowering, **PS:** Pods of Setting; line, year, harvest time x line, line x year $p \leq 0.01$; harvest time x year, harvest time x line x year: non significant

FIG. 4: Effects of harvest times on ADF ratio (%) of bitter vetch lines.



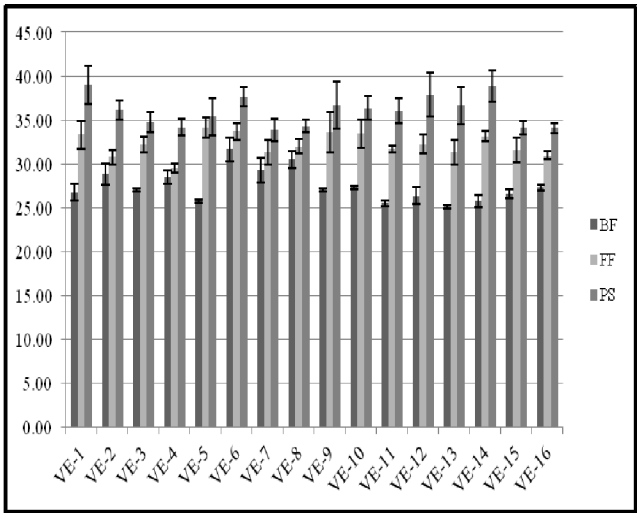
BF: Beginning of Flowering, FF: Full Flowering, PS: Pods of Setting; line, year, harvest time x line, line x year, harvest time x year, harvest time x line x year $p \leq 0.01$

highest value was seen in VE-1 with 38.96% (Fig 5).

The lowest crude protein ratio was observed in VE-4 at both flower-set and full-bloom respectively with 22.12% and 20.87%. The highest value was seen in VE-14 with 24.96% at flower-set and in VE-11 with 23.10% at full-bloom. Protein ratio at pod-set had the lowest value in VE-13 and had the highest value in VE-1 (Fig 6).

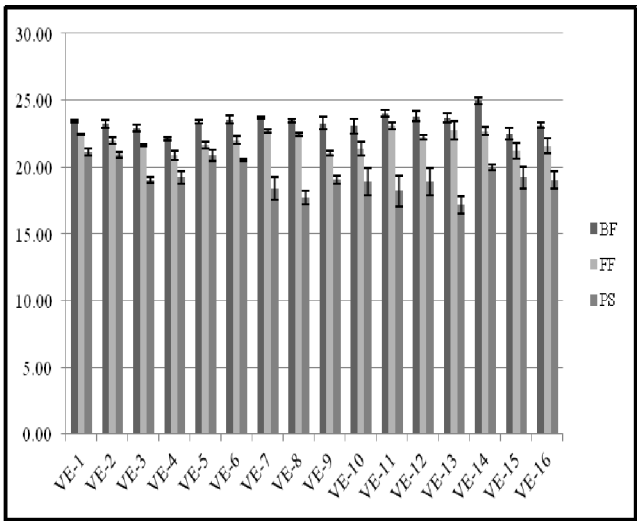
The highest crude ash ratio was observed in VE-2 at both flower-set and full-bloom respectively with 15.16% and 12.92%. The lowest value was

FIG. 5: Effects of harvest times on NDF ratio (%) of bitter vetch lines.



BF: Beginning of Flowering, **FF:** Full Flowering, **PS:** Pods of Setting; line, year, harvest time x line, line x year, harvest time x year, harvest time x line x year $p \leq 0.01$

FIG. 6: Effects of harvest times on crude protein (%) of bitter vetch lines.

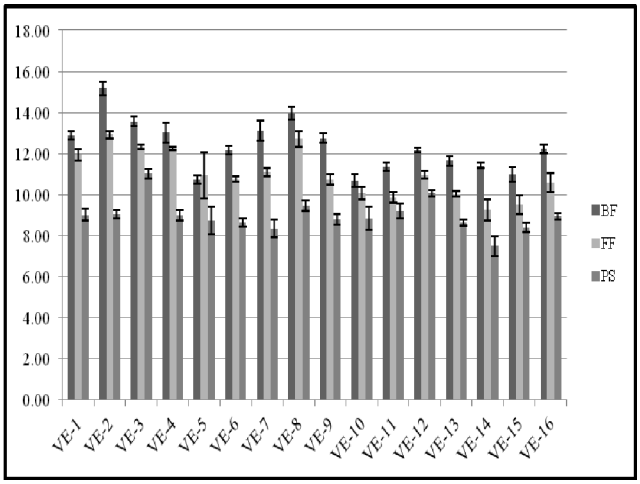


BF: Beginning of Flowering, **FF:** Full Flowering, **PS:** Pods of Setting; line, year, harvest time x line, line x year, harvest time x year, harvest time x line x year $p \leq 0.01$

seen in VE-10 with 10.70% at flower-set and in VE-14 with 9.25% at full-bloom. The crude ash ratio at pod-set had the lowest value in VE-14 with 7.49% and had the highest value in VE-3 with 11.03% (Fig 7).

While the lowest protein yield at flower-set was obtained from VE-7 with 427.5 kg/ha, the highest value was seen in VE-3 with 642.2 kg/ha. Protein yield at full-bloom varied between 525.9-822.4 kg/ha with lowest value in VE-14 and the

FIG. 7: Effects of harvest times on crude ash (%) of bitter vetch lines.



BF: Beginning of Flowering, **FF:** Full Flowering, **PS:** Pods of Setting; line, year, harvest time x line, line x year, harvest time x year, harvest time x line x year: $p \leq 0.01$

highest in VE-1. The lowest protein yield at pod-set was observes in VE-13 with 799.1 kg/ha, the highest value was seen in VE-5 with 1215.1 kg/ha (Fig 8).

Condensed tannin ratio at flower-set varied between 0.76-1.03% with the lowest value in VE-4 and the highest in VE-16. The lowest value was observed in VE-12 with 0.58% at full-bloom and in VE-15 with 0.48% at pod-set. The highest value was observed in VE-5 at both full-bloom and pod-set respectively with 0.77% and 0.61% (Fig 9).

The reason to have significant year x line interaction was mainly due to response of lines against lower precipitations and higher temperatures in the second year of the experiments. Some lines were able to sustain a certain yield levels under low precipitations. ADF and NDF ratios were higher in the second year. Such a difference was mostly due to positive relationship between ADF-NDF and temperature (Sürmen *et al.*, 2011; Galdamez-Cabrera *et al.*, 2002). Temperature was also effective on lower tannin ratios of the second year.

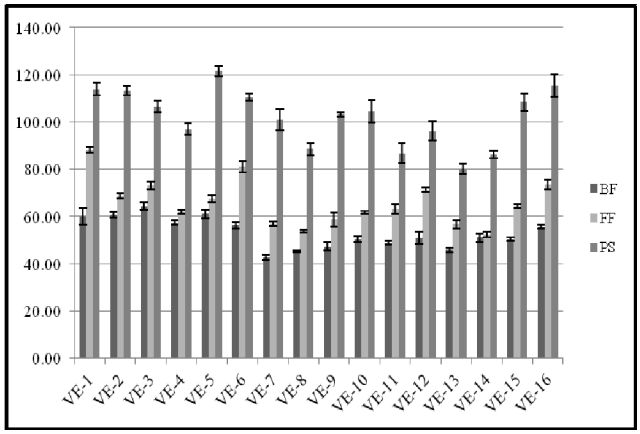
In general, green herbage and hay yields increased with the progression of harvest time. It is a natural phenomenon to have higher yields since structural members increase and new tissues are formed with the progression of ripening (Temel and Tan, 2002). Green herbage and hay yields of present study were similar to yields observed by Mihailovic et al., (2006); Ayan et al., (2006); Larbi *et al.*, (2011) and ICARDA (2008).

Ball et al., 2001 reported that the differences in dry matter and protein contents of plant species were mostly due to differences in their genetic characteristics, leaf, shoot and spike ratios, ripening periods, temperature and fertilization conditions. Decline in protein ratios with progression of ripening is generally related to both decreasing protein ratios in leaves and shoots and increasing ratio of shoots with low protein levels to entire plant and conversion of proteins into structural members (Nelson and Moser, 1994; Buxton, 1996; Kamalak *et al.*, 2005ab). Protein ratios of present study at full-bloom were similar to findings of Abd El-Moneim, (1993).

ADF and NDF ratios are significant quality indicators of forage crops (Aydin et al., 2010; Caballero et al., 1995) and such ratios should be low in quality forage since they obstruct the digestibility and consequently decrease the quality of forage. ADF and NDF ratios increase with the progression of growth (Kamalak et al., 2011). Findings of present study were relatively higher than the findings of Larbi et al., (2011).

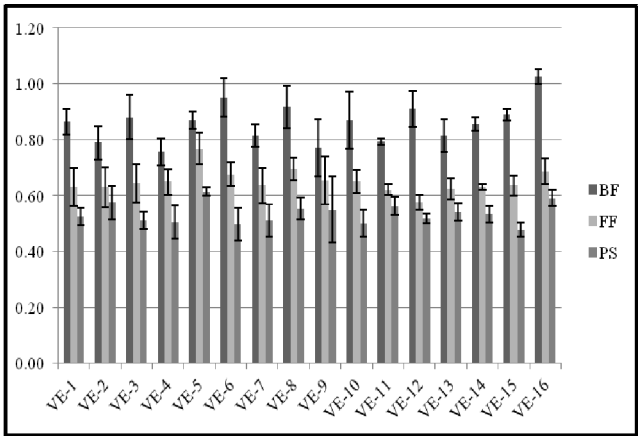
Low level of tannin (2-3% of DM) in ruminant diets may have a beneficial effect through reduced protein degradation in the rumen as a result of the formation of protein-tannin complexes (Barry, 1987). However, due to excessive formation of tannin-protein complexes, CP utilization could be restricted by high tannin level (%5 of DM) and protein may pass through the animal largely undigested (Kumar and Singh, 1984). High level of tannins can

FIG. 8: Effects of harvest times on protein yield (kg/ha) of bitter vetch lines.



BF: Beginning of Flowering, **FF:** Full Flowering, **PS:** Pods of Setting line, harvest time x line, line x year, harvest time x year, harvest time x line x year: $p \leq 0.01$; year: non significant

FIG. 9: Effects of harvest times on condensed tannin (%) of bitter vetch lines



BF: Beginning of Flowering, FF: Full Flowering, PS: Pods of Setting; line, year, harvest time x line, line x year, harvest time x line x year: $p \leq 0.01$; harvest time x year: non significant

adversely affect the microbial and enzyme activities (Singleton, 1981; Lohan *et al.,* 1983; Barry and Duncan 1984; Makkar *et al.*, 1989).

This study investigated the effects of harvest time on hay yield and quality of bitter vetch lines able to provide a quality forage source for livestock arid and semi-arid regions. Results indicated decreasing hay yields, crude protein, crude ash and condensed tanning ratios and increasing ADF and NDF ratio with the progression of harvest time. Therefore, pod-set period was determined as the best harvest time for bitter vetch. Further research may be carried to investigate the hay yield and quality parameters for harvest times implemented when the lower pods are full or the entire pods are full. Bitter vetch lines of VE-16, VE-5, VE-1, VE-2 and VE-6 are recommended for regional agriculture and breeding activities.

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