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TARIM ve DOĞA BİLİMLERİ
DERGİSİ

TURKISH
JOURNAL of AGRICULTURAL
and NATURAL SCIENCES

www.turkjans.com

Some Agronomical and Quality Traits in Nine Vetch (*Vicia ssp*.) Species Cultivated in Southeastern Anatolia, Turkey

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Received: 11.08.2014 Received in Revised Form: 31.12.2014 Accepted: 02.01.2015

Abstract

The study was performed to examine forage yield, seed yield and related parameters in nine vetch (*Vicia*) species. A randomized block design experiments with four replicates were carried out during the winter growing seasons of 2007–2008 and 2008–2009 at the experimental farm of the Faculty of Agriculture, Dicle University, Diyarbakir, Turkey. Over two growing seasons, we observed the following ranges of values across nine *Vicia* species: main stem number, 2.18–3.67; main stem thickness, 1.42–4.07 mm; plant height, 40.30–82.16 cm; fresh forage yield, 8.46–22.73 t ha^{-1}; dry matter yield, 2.39–5.23 t ha^{-1}; dry matter crude protein content 13.64–19.50%, dry matter crude protein yield 0.326–0.961 t ha^{-1}; number of pods per plant, 7.59–16.03; number of seeds per pod, 2.83–6.02; 1000-seed weight, 41.91–219.9 g; seed yield, 0.74–2.84 t ha^{-1}; seed crude protein content 23.29–45-73%; seed crude protein yield 0.74–2.84 t ha^{-1}; biological yield, 4.26–12.75 t ha^{-1}; harvest index, 16.57–28.34%; and seed germination rate, 7.63–97.00%. Results of the study showed that *Vicia narbonensis*, *Vicia sativa, Vicia. sericocarpa var. serico* species were more productive for fresh forage yield, dry matter yield, dry matter crude protein content and dry matter crude protein yield traits. On the other hand, for seed yield and seed crude protein yield traits *Vicia narbonensis* was found by far as the most productive species. With very high seed crude protein content, *Vicia michauxii var*. *stenophy* was found remarkable.

Key Words: Vetches (*Vicia* ssp.), forage yield, crude protein content, seed yield, yield components

Güneydoğu Anadolu Bölgesi Koşullarında Ekilen Dokuz Fiğ (*Vicia ssp*.) Türünde Bazı Tarımsal ve Kalite Özellikleri

Özet

Bu araştırma, dokuz fiğ türünde (*Vicia*) ot verimi, tohum verimi ve bu verimlerle ilişkili özellikleri incelemek amacıyla ele alınmıştır. Araştırmada denemeler, Dicle Üniversitesi Ziraat Fakültesi deneme alanlarında, 2007-08 ve 2008-09 ekim sezonlarında, kışlık olarak, tesadüf blokları deneme desenine göre, dört tekerrürlü olarak yürütülmüştür. İki yıllık gözlem verilerine göre dokuz fiğ türünde incelenen özellikler aşağıdaki şekilde değişim göstermiştir. Ana sap sayısı, 2.18–3.67 adet; ana sap kalınlığı, 1.42–4.07 mm; bitki boyu 40.30–82.16 cm; yeşil ot verimi 8.46–22.73 t ha^{-1}; kuru ot verimi 2.39–5.23 t ha^{-1}; kuru ottaki ham protein oranı %13.64–19.50, kuru ot ham protein verimi 0.326–0.961 t ha^{-1}; bitkide bakla sayısı 7.59–16.03 adet, baklada tane sayısı 2.83–6.02 adet; bin dane ağırlığı 41.91–219.9 g; tohum verimi 0.74–2.84 t ha^{-1}; tohumdaki ham protein oranı %23.29–45-73; tohum ham protein verimi 0.227-0.858 t ha^{-1}; biyolojik verim 4.26–12.75 t ha^{-1}; hasat indeksi %16.57–28.34 ve tohum çimlenme oranı %7.63–97.00. Araştırma sonucuna göre; *Vicia narbonensis*, *Vicia sativa, Vicia. sericocarpa var. serico*. türleri yeşil ot verimi, kuru ot verimi, kuru ottaki ham protein oranı ve kuru ot ham protein verimi özellikleri bakımından daha verimli bulunurken, *Vicia narbonensis* türü tohum verimi ve tohum ham protein verimi özellikleri bakımından en verimli tür olmuştur. En yüksek tohumdaki ham protein oranıyla *Vicia michauxii var. stenophy* türü dikkat çekici bulunmuştur.

Anahtar Kelimler: Fiğler (*Vicia* ssp.), ot verimi, ham protein içeriği, tohum verimi, verim kompenentleri

Introduction

Turkey, located within the Mediterranean, Irano-Turanian, and Euro-Siberian floristic regions, is one of the wealthiest countries in the world in terms of natural flora, especially with regard to vetch (*Vicia*) species. According to Davis and Plintman (1970), the genus *Vicia* includes approximately 150 species, and 59 of these are endemic to Turkey. In total, 122 taxa (66 species, 27 subspecies, and 29 varieties) of *Vicia* have been identified within Turkey (Basbag et al., 2013).

Vicia species are of a great agronomical importance and commonly grown annual legume species in Turkey. They are used for multiple purposes, but are particularly important as forage crops. Fresh or dried vetch hay is palatable and nutritious for livestock, and the high protein content of vetch seeds makes them useful as a concentrated feed (Kendir, 1999). Moreover, vetches can be used as a pasture plant, alone or in combination with other species. In addition, vetches are useful as a rotation crop due to the presence of symbiotic bacteria (*Rhizobium* spp.) in vetch roots that fix atmospheric nitrogen in the soil, allowing the plant to act as a 'green manure' in organic farming (Acikgoz, 2001).

According to Sayar et al. (2010), existing quality roughage, obtaining forage from rangeland and forage crops, in Turkey is sufficient to feed only half of the nation's livestock. The situation is most severe in Southeastern Anatolia, where quality roughage production is sufficient for only 33.39% of the livestock. Therefore, livestock in this region are fed with low-quality roughage, such as cereal chaff and straw, which is sufficient to satiate hunger, but does not meet the animals' nutritional requirements. Accordingly; the yield of obtained from livestock in the region is not at the desired level (Sakarya et al., 2008; Sayar et al., 2014). According to Yucel et al. (2009) developing new and more suitable forage crops to meet the needs of an expanding livestock population is essential for agricultural development in Southeastern Anatolia.

In previously investigations made by different researchers in different ecologies on *Vicia* species on forage and seed yields and their effecting important traits were determined as follows; plant height 15.0-157.3 cm; main branch 1.6-6.2; fresh forage yield 3.10-39.45 t ha^{-1}; dry matter yield 0.82.5- 6.22 t ha^{-1}. Pod number per plant 2.0-82.0; seed number per pod 2.8-9.2; 1000 seed weight 22.85-241.4 g; seed yield 0.16-4.20 t ha^{-1}; biological yield 1.07-17.60 t ha^{-1}; dry matter crude protein yield 0.30-1.87 t ha^{-1}, seed crude protein yield 0.11-0.61 t ha^{-1}; harvest index 13.4-58.2% (Silbir et al., 1994: Acikgoz et al., 1996; Bucak and Anlarsal, 1996; Anlarsal et al., 1999; Sabanci et al., 1996; Buyukburc and Karadag, 1999; Altinok and Hakyemez, 2000; Balabanli and Kara, 2003; Basbag, 2004; Tamkoc and Avci, 2004; Uzun et al., 2004; Albayrak et al., 2005; Celen et al., 2005; Cakmakci et al., 2006; Gurmani et al., 2006; Firincioglu et al., 2009; Sayar et al., 2013).

The objective of this study was to determine some important agronomical and quality traits of nine *Vicia* species grown over the winter in Diyarbakir, a province within Southeastern Anatolia.

Materials and Methods

This research was conducted during the 2007–2008 and 2008–2009 growing seasons on the experimental farm at the Faculty of Agriculture, Dicle University, Diyarbakir, Turkey (37°53´22.1˝N, 40°16´27.1˝E; altitude, 655 m). Nine vetch species were examined in total. Four cultivars were provided by Dicle University Faculty of Agriculture, including the 'Gorkem' common vetch cultivar (*Vicia sativa* L.), the 'Kiralkizi' cultivar (*Vicia sericocarpa* Fenzl. var. *sericocarpa*), the 'Dicle' common vetch cultivar [*Vicia sativa* L. subsp. *nigra* (L.) Ehrh. var. *nigra*], and the 'Ozgen' narbon bean cultivar (*Vicia narbonensis* L.). In addition, several native species were examined, including Hungarian vetch (*Vicia pannonica* Crantz.), hairy vetch (*Vicia villosa* Roth.), bitter vetch [*Vicia ervilia* (L.) Wild.], *Vicia michauxii* var. *stenophylla* Boiss., and *Vicia peregrina* L.

The climate of the region is characterized by a semi-arid climate (humid winters and dry summers); rainfall distribution is variable within and among years. Climatic data during the years of study and long term means are shown in Table 1. The average temperatures for long years are minimum 1.7 ^{o}C in January, maximum 26.0 ^{o}C in June. Total rainfall amount was 453.6 mm year^{-1} and mean relative humidity is 63.9% (Table 1). The total falling rainfall amount of both of the years was far below the average of long years. However, due to favorable climatic conditions, especially higher amount of falling precipitation in the second year (2008-2009). Hay and seed yields of obtained from the genotypes in the second year were found superior than the first year yields. Due to the less rainfall, the trials was irrigated for one time during flowering stage of plants in both of the growing seasons.

According to the results of the made soil analysis, the soil of experimental area has clay loam soil texture with high lime content (14.0%), low salt (0.07%), alkaline (pH 7.7), poor in phosphorus (P_2O_5 32.5 kg ha^{-1}) and organic matter (1.52%), but it is rich in terms of potassium (K_2O 448 kg ha^{-1}) content. In addition, salt levels and water permeability of the soil is good. The experimental area was fertilized with 40 kg ha^{-1} nitrogen (N) and 102 kg ha^{-1} P_2O_5 before the sowings.

Over 2 years, field experiments were carried out using a complete randomized block design with four replications. Each plot consisted of six rows (6 m in length) spaced 20 cm apart. Sowing dates for the 2 years were 12 November 2007 and 20 November 2008. At the time of sowing, the soil moisture content was sufficient for seed germination. Half of each plot was harvested in May to calculate the fresh forage yield and dry matter yield, and the other half was harvested in June to calculate the seed yield. However, the first and last 0.5 m of each row were not included in the experimental observations to avoid margin effects. Forage and seed quality parameters were determined according to the technical instructions for leguminous forage crops published by the Seed Registration and Certification Center, Ankara, Turkey (2001).

Genetic verification and chromosomal analyses for the nine *Vicia* species were performed at the Biology Department of the Faculty of Science at Dicle University using germinating seeds. At the end of germination, roots were cut to 1–1.5-cm lengths and soaked in 1,4-dichlorobenzene for 4 h. Next, the materials were fixed in Carnoy fixative (3:1) and stored in alcohol (70%) in a refrigerator (Elci, 1994). Roots were hydrolyzed in 1 N HCl at 60°C for 15 min. Samples were subjected to Feulgen staining to visualize chromosomal material. After pressing samples under a coverslip, they were observed under a light microscope (Sahin and Babac, 1990, 1995).

Germination data were arcsine-transformed before statistical analysis (Zar, 1999). Data were compared using analysis of variance (ANOVA) in the MSTAT-C statistical package version 3.00/EM (Freed et al., 1989). Differences among means were compared using the least significant difference (LSD) test at the 0.05 probability level (Steel and Torrie, 1960).

Table 1. Mean air temperatures (°C), the amount of total rainfall (mm) and mean relative humidity (%) of the research area (Anonymous, 2009)

Months	Mean air temperatures (°C)			Total rainfall (mm)			Mean relative humidity (%)		
	2007-2008	2008-2009	Long years	2007-2008	2008-2009	Long years	2007-2008	2008-2009	Long years
November	8.6	10.1	9.6	0	50.5	54.1	48.8	51	68
December	2.4	2.2	4.1	43.5	52.2	71.5	61.3	57	77
January	-2	1.4	1.7	25	12.4	73.6	53	73	77
February	1.7	5.6	3.5	40.8	70	67	53	83	73
March	11.6	7.9	8.2	17.3	63.9	67.9	52	74	66
April	16.8	11.8	13.8	19	43.7	70.5	39	71	63
May	18.7	18.2	19.2	34.9	9.1	42.1	35	52	56
June	27.4	25.9	26	2.2	25.8	6.9	25	32	31
Mean/Total	10.7	10.4	10.8	182.7	327.6	453.6	45.9	61.6	63.9

Table 2. Chromosome numbers and some agronomical properties of vetch species

Species	Chromo. number	Main branch Number		Stem thickness (mm)		Plant height (cm)		Fresh forage yield (t ha^{-1})	
Vicia sativa	12	3.27	c	2.30	b	62.98	c	18.32	b
V. sericocarpa var. serico.	12	3.52	abc	1.89	d	58.51	d	17.74	b
V. sativa nigra var nigra	12	2.93	d	2.10	c	55.93	d	15.44	c
V. narbonensis	14	2.18	f	4.07	a	66.73	b	22.73	a
V. pannonica	12	2.58	e	1.67	e	64.89	bc	12.91	e
V. michauxii var. stenophylla	14	3.67	a	1.58	e	44.79	e	8.46	h
V. peregrina	14	3.56	ab	1.42	f	45.10	e	10.10	f
V. villosa	14	3.37	bc	2.29	b	82.16	a	14.59	d
V. ervilia	14	2.62	e	2.03	c	40.30	f	9.93	g
Mean		3.08		2.15		57.93		14.57	
Cv		9.14		4.05		5.00		5.17	
LSD (0.05)		0.283		0.088		2.91		0.76	

*Means shown with the same letter in the same column are not significantly different at 0.05 probability level.

Results and Discussion

Chromosomal analysis revealed that chromosome numbers ranged from 12 to 14 among the *Vicia* species (Table 2). Although 2*n* = 12 chromosomes were found in *V. sativa*, *V. sericocarpa* var. *sericocarpa*, *V. sativa* subsp. *nigra* var. *nigra*, and *V. pannonica*, 2*n* = 14 chromosomes were found in *V. narbonensis*, *V. michauxii* var. *stenophylla*, *V. peregrina*, *V. villosa*, and *V. ervilia.* These results are consistent with previous studies in which 2*n* = 12 chromosomes were found in *V. sativa* (Bucak and Anlarsal, 1996; Sevimay et al., 2005) and *V. pannonica* (Yamamoto, 1973), and 2*n* = 14 chromosomes were found in *V. villosa* (Gaffarzadeh-Namazi et al. 2008), *V. narbonensis* (Gulcan and Anlarsal, 2001), and *V. ervilia* (Ladizinsky and Oss, 1984). However, this is the first report regarding chromosome numbers in *V. sericocarpa* var. *sericocarpa*, *V. sativa* subsp. *nigra* var. *nigra*, *V. michauxii* var. *stenophylla*, and *V. peregrina*.

There were statistically significant differences (*P<0.05*) among vetch species for all of the investigated traits (Table 2,3,4,5). Main stem numbers per plant ranged from 2.18 to 3.67 among the nine vetch species. The highest main stem numbers were found in *V. michauxii* var. *stenophylla*, followed by *V. peregrina* and *V. sericocarpa* var. *sericocarpa*, whereas the lowest main stem number per plant was recorded in *V. narbonensis* (Table 2). Mihailoviç et al. (2006) reported similar values for *V. sativa* (2.3–3.3), *V. villosa* (3.8), and *V. ervilia* (2.6), and Sayar et al. (2012) found similar values for *V. pannonica* (2.23–3.06).

Table 3. Some agronomical properties of vetch species

Species	Dry matter yield (t ha^{-1})		Pod number plant^{-1}		Seed number pod^{-1}		1000 seed weight (g)	
Vicia sativa	4.58	b	9.19	cd	6.02	a	51.30	d
V. sericocarpa var. serico.	4.36	bc	10.63	b	3.51	f	64.87	c
V. sativa nigra var nigra	4.17	c	8.43	de	5.64	b	51.18	d
V. narbonensis	5.23	a	9.73	c	4.96	c	219.9	a
V. pannonica	2.94	e	8.80	de	4.08	d	41.91	f
V. michauxii var. stenophy.	2.40	f	7.59	f	3.77	e	83.00	b
V. peregrina	2.99	e	8.28	fe	3.81	e	48.29	e
V. villosa	3.31	d	8.05	fe	4.20	d	47.06	e
V. ervilia	2.39	f	16.03	a	2.83	g	48.60	e
Mean	3.60		9.64		4.31		72.90	
Cv	6.41		7.90		4.39		2.96	
LSD (0.05)	0.23		0.77		0.19		2.17	

*Means shown with the same letter in the same column are not significantly different at 0.05 probability level.

According to Sayar and Han (2014) main stem thickness in annual forage species has both positive and negative aspects. On the one hand, a genotype with a higher stem thickness it is more resistant to lodging and laying, while on the other hand a higher stem thickness causes an increased leaf-to- stem ratio in the forages. Also, according to Ball (2001) and Tan et al (2013). This decreases the digestibility and crude protein content of the forage, and leads to a resultant decrease in forage quality. In the study, main stem thickness varied from 1.42 mm to 4.07 mm among the *Vicia* species. The highest plant main stem thickness was determined in *V. narbonensis,* whereas the lowest value was determined in *V. peregrine* (Table 2). Accordingly, following cited literature confirm our main stem thickness findings. Van de Wouw et al. (2003) in *V. sativa* 1.8-3.8 mm, Basbag and Koc (2010) in *V. villosa* 2.07-2.27 mm and Sayar et al. (2012) in *V. pannonica* 1.62-2.27 mm, Sayar and Han (2014) in *V. narbonensis* 3.32-4.97 mm.

Plant heights changed among the nine vetch species from 40.30 cm to 82.16 cm. Although the highest plant height was recorded in *V. villosa*, the lowest was recorded in *V. ervilia* (Table 2). Similarly; Mihailoviç et al. (2006) determined the highest plant height in *V. villosa,*(158 cm) and lowest in *V. ervilia* (60 cm) in Serbia conditions. However, their plant height values were higher than ours. The cause of their plant height findings higher than ours is that Serbia ecological conditions, rainier and cool, more available than in Diyarbakır ecological conditions for growing of *Vicia* species.

The combined variance analysis over the two years showed that fresh forage yields among the vetch species ranged from 8.46 to 22.73 t ha^{-1}. The highest fresh forage field was obtained from *V. narbonensis*, and the lowest from *V. michauxii* var.

stenophylla. Fresh forage yield from the remaining species was ranked as follows: *V. sativa*, 18.32 t ha^{-1}; *V. sericocarpa* var. *sericocarpa*, 17.74 t ha^{-1}; *V. sativa nigra* var. *nigra*, 15.44 t ha^{-1}, *V. villosa*, 14.59 t ha^{-1}; *V. pannonica*, 12.91 t ha^{-1}; and *V. ervilia*, 9.93 t ha^{-1} (Table 2). Consistent with our findings, previous studies reported fresh forage yields of 5.55–14.44 t ha^{-1} for *V. ervilia* (Ayan et al., 2006), 12.27–23.36 t ha^{-1} for *V. pannonica* (Sayar et al., 2012), 10.86–20.10 t ha^{-1} for *V. sericocarpa*, 10.44–17.92 t ha^{-1} for *V. peregrina*, and 20.10–21.66 t ha^{-1} for *V. sativa* (Basbag, 2004), 19.42-37.95 t ha^{-1} for *V. narbonensis.*

Table 4. Some agronomical properties of vetch species

Species	Seed yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest Index (%)		Germination rate (%)	
Vicia sativa	1.53	b	7.20	bc	21.42	d	97	a
V. sericocarpa var. serico.	1.48	bc	7.39	b	20.17	e	42.25	e
V. sativa nigra var nigra	1.35	d	7.07	c	19.29	e	84.88	c
V. narbonensis	2.84	a	12.75	a	22.49	cd	94.38	b
V. pannonica	0.80	g	4.85	f	16.57	f	85.75	c
V. michauxii var. stenophy.	1.10	f	4.31	g	28.34	a	7.63	g
V. peregrina	1.23	e	5.31	e	25.42	b	11.63	f
V. villosa	0.74	g	4.26	g	17.65	f	92.75	d
V. ervilia	1.43	c	6.25	d	22.89	c	87.13	c
Mean	1.39		6.60		21.58		67.04	
Cv	4.43		4.2		5.62		5.41	
LSD (0.05)	0.06		0.3		1.22		2.99	

*Means shown with the same letter in the same column are not significantly different at 0.05 probability level.

To close the quality roughage gap in Turkey, crops with higher forage quality and greater dry matter yields are necessary. In this study of nine vetch species, *V. narbonensis* produced the highest dry matter yield (5.23 t ha^{-1}), whereas *V. ervilia* showed the lowest dry matter yield (2.39 t ha^{-1}) (Table 3). However, although fresh forage and dry matter yields from *V. narbonensis* were higher than from any other vetch species examined here, forage quality in this species was lower due to its increased stem thickness and higher stem:leaf ratio. Accordingly, *V. narbonensis* may be more useful as a green manure or as a source of seeds for feed. Other productive species in terms of dry matter yield were *V. sativa* (4.58 t ha^{-1}), *V. sericocarpa* var. *sericocarpa* (4.36 t ha^{-1}), *V. sativa nigra* var. *nigra* (4.17 t ha^{-1}), and *V. villosa* (3.31 t ha^{-1}; Table 3). Abd El Moneim (1993) reported that dry matter yield in *V. sativa, V. ervilia* and *V. villosa* were respectively 3.13-3.59 t ha^{-1}, 2.33-2.71 and 5.79-636 t ha^{-1} in ecological conditions of Northwest Syria.

Pod number per plant, seed number per pod, and 1000-seed weight are important parameters used to assess seed yield for feed grain and seed production. In this study, pod numbers varied greatly among species, from 7.59 to 16.03 pods $plant^{-1}$; seed number varied from 2.83 to 6.02 seeds pod^{-1} and 1000-seed weight from 41.91 to 219.9 g. Although *V. ervilia* showed the greatest number of pods per plant, the most seeds per pod were found in *V. sativa.* The highest 1000-seed weight value was recorded in *V. narbonensis*, and the lowest in *V. pannonica* (Table 3). In our study, low 1000 seed weight in *V. pannonica* was likely due to its late flowering time. The early suppression high temperatures in the region coincided with flowering time of *V. pannonica* and similar late flowering species and this negatively affected plant pollination and fertilization of the species. Eventually, this led to both lower seed yield and small and scrawny seeds. Our findings for seeds per pod and 1000-seed weight are largely in agreement with those of Kendir (1999) for *V. sativa*, *V. pannonica*, and *V. villosa*, which were in Ankara conditions. However, our findings for pods per plant were lower than those reported by Kendir (1999) for *V. sativa*, *V. pannonica*, and *V. villosa.*

Large differences in seed yield were observed among the vetch species examined here. By far the greatest seed yield was attained from *V. narbonensis* (2.84 t ha^{-1}), whereas the lowest yields were obtained from *V. villosa* (0.74 t ha^{-1}) and *V. pannonica* (0.80 t ha^{-1}; Table 4). As stated above, late flowering in these species may have led to the low seed yield. These findings are consistent with those of Abd El Moneim (1993), who reported seed yields of 0.718–1.405 t ha^{-1} for *V. sativa*, 0.976–1.267 t ha^{-1} for *V. ervilia*, and 0.541–0.710 t ha^{-1} for *V. villosa*. In contrast, Kendir (1999) reported much higher seed yields for *V. sativa* (1.625 t ha^{-1}), *V. pannonica* (1.263 t ha^{-1}), and *V. villosa* (1.325 t ha^{-1}). These differences are likely the result of genetic and ecological variability.

Table 5. Crude protein content and crude protein yield in dry matter and seeds of vetch species

Species	Dry matter crude protein content (%)	Dry matter crude protein yield (t ha^{-1})	Seed crude protein content (%)	Seed crude protein yield (t ha^{-1})
Vicia sativa	19.50 a	0.893 b	31.70 b-d	0.485 bc
V. sericocarpa var. serico.	16.56 a-d	0.722 c	32.03 bc	0.474 c
V. sativa nigra var nigra	14.24 cd	0.594 d	33.19 bc	0.448 d
V. narbonensis	18.37 ab	0.961 a	30.21 cd	0.858 a
V. pannonica	15.41 b-d	0.453 e	28.38 d	0.227 g
V. michauxii var. stenophy.	17.63 a-c	0.423 e	45.73 a	0.503 b
V. peregrina	15.22 b-d	0.455 e	34.23 b	0.421 e
V. villosa	17.46 a-c	0.578 d	31.35 b-d	0.232 g
V. ervilia	13.64 d	0.326 f	23.29 e	0.333 f
Mean	16.45	0.6	32.23	44.25
Cv	7.46	6.51	6.11	5.17
LSD (0.05)	3.524	0.039	3.383	0.023

*Means shown with the same letter in the same column are not significantly different at 0.05 probability level.

Biological yields among the vetch species were differed from 4.31 t ha^{-1} to 12.75 t ha^{-1}. The highest biological yield was recorded in *V. narbonensis,* while the lowest biological yield was recorded in *V. villosa* and *V. michauxii var. stenophylla* (Table 4). According to Abd El Moneim (1993) biological yield in *V. sativa, V. ervilia* and *V. villosa* varied respectively 2.564-4.532 t ha^{-1}, 2.788-3.570 t ha^{-1} and 3.426-5.590 t ha^{-1}. When compared our findings with findings of Abd El Moneim (1993), both of the researches findings related to biological yield in *V. sativa and* in *V. villosa are* in harmony with each other.

Vicia michauxii var. *stenophylla* had the highest harvest index, averaging 28.34%, whereas *V. pannonica* showed the lowest mean harvest index (16.57%; Table 4). Van De Wouw et al. (2003) reported widely ranging harvest index values among vetch species (2–25%); the highest harvest index was observed for *V. amphicarpa*, and the lowest for *V. nigra*. In addition, the authors showed that the percentage of shattered pods and seeds was very high in some vetch species, which may also have contributed to low harvest index values, particularly for *V. nigra* species.

Seed germination rates ranged from 7.63% - to 97.00% in the vetch species examined here. The highest germination rate was recorded in *V. sativa* and the lowest in *V. michauxii* var. *stenophylla*. The germination rate of *V. peregrina* seeds was 11.63% (Table 4). Basbag et al. (2011) examined 30 forage crops species and found that seed germination rates varied from 4.9% to 90.0%; the authors noted that the low germination rates observed in wild vetch species were likely due to their tough, impermeable seed coat. However, such difficulties in seed germination can be resolved through mechanical or chemical methods.

Significant differences were determined among the vetch species in terms both dry matter crude protein content and dry matter crude protein yield traits. Although dry matter crude protein content changed among the vetch species from 13.64% to 19.50%, dry matter crude protein yield changed among the species from 0.326 to 0.961 t ha^{-1}. Dry matter crude protein content of *V. sativa, V. sericocarpa var. serico., V. narbonensis, V. villosa* and *V. michauxii var. stenophy.* were found higher than the other vetch species. However, by far dry matter crude protein yield of *V. narbonensis* was significantly higher than all of the vetch species. This largely stemmed from high fresh forage and dry matter yields of *V. narbonensis*. Even so, we generally recommend that cultivation *V. narbonensis* should be preferred for green manure and seed yield purposes. Due to its high stem/leaf ratio and emerging problems in its forage drying, fresh forage and dry matter yield aimed *V. narbonensis* cultivations are not usually preferred. Previously cited dry matter crude protein content by Rahmati et al. (2012) in *V. narbonensis* (19.0%) and by Yücel et al. (2012) in *V. sativa* (14.68-23.90%) confirmed our dry matter crude protein content data. On the other hand, dry matter crude protein yield in *V. sativa* and in *V. pannonica* were reported as 0.564 t ha^{-1} and 0.401-0.771 t ha^{-1} by Rahmati et al. (2012) and Yolcu et al. (2012) respectively.

Legumes usually are well known for their high seed crude protein content. As a legume genus, *Vicia* is of highly crude protein content seeds too. According to Nezar et al. (2009) seed crude protein content of *V. sativa* genotypes varied between 39.3% and 48.7% depend on seed maturity stages. For this reason, seeds of *Vicia* genus are used as a concentrate feed, helping consumption of straw, in animal nutrition. In the research, while seed crude protein content among *Vicia* species varied from 23.29% to 45.73%, seed crude protein yield changed from 0.74 t ha^{-1} to 0.858^{-1}. Even though the highest seed crude protein content was recorded in *V. michauxii var. stenophy*, the lowest one was recorded in *V. ervilia* (Table 5). Similarly, Emre (2011) reported that seed crude protein content of *V. michauxii var. stenophy* was higher most of the *Vicia* species. On the other hand, *V. narbonensis* did not have the highest crude protein content, owing to its high seed yield, its seed crude protein yield was found as the highest among the *Vicia* species. It was drawn attention point that despite its high seed crude protein content, *V. michauxii var. stenophy* took place in the middle of range in term of seed crude protein yield because of its low seed yield.

Conclusions

In conclusion, the nine *Vicia* species showed great variation with respect to the examined traits. *Vicia narbonensis*, *Vicia sativa, Vicia. sericocarpa var. serico*. species were found more productive for fresh forage yield, dry matter yield and dry matter crude protein content and dry matter crude protein yield traits. On the other hand, for seed yield and seed crude protein yield traits *Vicia narbonensis* was found by far as the most productive species. With very high seed crude protein content, *V. michauxii var*. *stenophy* was found remarkable.

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