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Full length research paper

Nutritional Profiles and Traits Relationships of Selected Vetch Species and their Accessions Grown under Nitosol and Vertisol Conditions in the Central Highlands of Ethiopia

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Abstract

The study was conducted to evaluate the nutritional differences and character associations of vetch species and their accessions grown under nitosol and vertisol conditions and to compare their performance at Holetta and Ginchi in the central highlands of Ethiopia. The experiment was conducted in randomized complete block design with three replications. Analysis of variance procedures of SAS general linear model was used to compare treatment means. The nutritive values of vetch species and their accessions were comparatively higher at Holetta than Ginchi for most measured parameters. Intermediate (Vicia dasycarpa and Vicia atropurpurea) to late (Vicia villosa) maturing vetch species and their accessions had relatively higher ash content than early maturing (Vicia narbonensis and Vicia sativa) vetch species and their accessions. Comparatively higher crude protein content was recorded for intermediate maturing vetch species whereas lower crude protein content was obtained from early and late maturing species at both locations. Early maturing vetch species and their accessions had lower in-vitro dry matter digestibility compared to intermediate to late maturing vetch species and their accessions. Vicia narbonensis and Vicia sativa and their accessions which have an erect growth type and early maturity had comparatively higher neutral detergent fiber content than Vicia dasycarpa, Vicia atropurpurea and Vicia villosa which have an intermediate to late maturity and creeping type of vetch species and their accessions. The correlation analysis indicated that forage dry matter yield was positively correlated with crude protein, crude protein yield, and in-vitro dry matter digestibility, whereas negatively correlated with neutral detergent fiber content. Generally, vetch species and their accessions had different nutritional profiles and traits association in the central highlands of Ethiopia.

Keywords: Accession, Agro-morphological trait, Correlation, Nutritional trait, Vetch species

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Introduction

Traditional livestock production system mainly depends upon poor pasturelands and crop residues which are usually inadequate to support reasonable livestock production (Assefa, 2005). Poor nutrition is one of the major constraints to livestock productivity in sub-Saharan Africa (Osuji *et al*., 1993) and it results in low productivity, growth rates and reproduction as well (Getu *et al*., 2012). Despite enormous contribution of livestock to the livelihood of farmers, availability of poor quality feed resources remains to be the major bottleneck to livestock production in the highlands of Ethiopia (Seyoum and Zinash, 1995). This is because animals thrive predominantly on high fiber feeds which are deficient in essential nutrients for microbial fermentation. The variation in morphological characteristics such as leaf, stem, pod and flower fractions of forage accounts for parts of the difference in feed quality. Higher concentration of cell wall constituents were related to reduced intake (Sarwar *et al*., 2002) and low digestibility in ruminants. Riday *et al*., (2002) suggested that the genetic variation of fiber content is one of the main reasons of forage quality variation. This variation in morphological characteristic is important in the selection of forage crops, which are agronomically suitable and used for various purposes (Getnet Assefa and Ledin, 2001).

Vetch is the most important and widely cultivated annual forage legume in the highlands farming system of Ethiopia through different production strategies. One attraction of vetch is its versatility, which permits diverse utilization as either ruminant feed or green manure. As a legume crop, it provides nitrogen to the soil and reduces the incidence of diseases in succeeding non-leguminous crop. It grows well on the reddish brown clay soils and the black soils of the highland areas. It has been grown successfully in areas of acid soil with pH of 5.5-6. It is reported that vetches are rich in protein, minerals, lower fiber content and higher level of crude protein. Vetches are an important source of protein and have a major role in animal nutrition, and it is essential to know the relationship between yield and its components in vetch breeding program. Future program in vetch species research will focus on improving the existing varieties and developing new ones to address the future feed demands. One of the main concerns in vetch species productions as well as in many agricultural crops production is to harvest high yield and quality crops. Since genotypes and environmental factors are the main components determining yield and quality in crops, a primary objective should be the determination of effects of genotypic factors in selection.

Herbage yield in combination with other characteristics like maturity, proportions of morphological fractions and nutritive value of the herbage yield are useful considerations in selecting the best variety for forage production (Arelovich *et al*., 1995). Research results indicate that variation in lucerne forage digestibility and intake is correlated with the presence of significant genetic variation (Katić *et al*., 2008). Species of vetch have different characteristics in terms of growth habit, days to maturity, morphological fractions, and climatic adaptation. These differences in genetic characteristics are the basis for variation in nutritive values and also determine the production, utilization and the various management practices. When one selects varieties for certain desired trait, there is a need to consider the relationships between various production traits to select varieties with most of the traits compromised (Getnet *et al*., 2003). Therefore, this experiment was designed to assess the nutritive values and characters associations of different vetch species and their accessions grown under nitosol and vertisol conditions and to compare their performance at Holetta and Ginchi in the central highlands of Ethiopia.

Materials and Methods

Descriptions of the Test Environments

The experiment was conducted at Holetta Agricultural Research Center (HARC) and Ginchi sub center during the main cropping season of 2009 under rain fed condition. HARC is located at 9°00'N latitude, 38°30'E longitude at an altitude of 2400 m above sea level. It is 34 km west of Addis Ababa on the road to Ambo and is characterized with the long term average annual rainfall of 1055.0 mm, average relative humidity of 60.6% and average maximum and minimum air temperature of 22.2°c and 6.1°c, respectively. The rainfall is bimodal and about 70% of the precipitation falls in the period from June to September while the remaining 30% falls in the period from March to May (EIAR, 2005). The soil type of the area is predominantly red nitosol, which is characterized by an average organic matter content of 1.8%, total nitrogen 0.17%, pH 5.24, and available phosphorus 4.55ppm (Gemechu, 2007). Ginchi sub center is located at 75 km west of Addis Ababa in the same road to Ambo. It is situated at 9°02'N latitude and 38°12'E longitude with an elevation of 2200m above sea level and characterized with the long term average annual rainfall of 1095.0 mm, average relative humidity of 58.2% and average maximum and minimum air temperature of 24.6°c and 8.4°c, respectively. The site has a bimodal rainfall pattern with the main rain from June to September and short rain from March to May (EIAR, 2005). The soil of the area is predominately black clay vertisol with organic matter content of 1.3%, total nitrogen 0.13%, pH 6.5 and available phosphorus 16.5 ppm (Getachew *et al*., 2007).

Experimental Treatments and Design

The study was executed using 20 accessions from five vetch species (Table1). All accessions of *Vicia narbonensis*, *Vicia villosa*, and *Vicia sativa* were introduced from International Center for Agricultural Research in the Dry Areas (ICARDA); *Vicia dasycarpa* and *Vicia atropurpurea* accessions were initially introduced from Australia. Most of the accessions of vetch species were selected on the basis of their adaptation to the central highlands of Ethiopia from the previous screening trials. The experimental fields were prepared following the recommended tillage practice and a fine seed bed was used at planting. At Ginchi site, sowing was done on camber-beds to improve drainage and reduce water-logging problems of vertisol. The experiment was conducted on a randomized complete block design with three replications. Seeds were drilled in rows of 30 cm on a plot size of 2.4 m x 4 m= 9.6 m^2, which consisted of 8 rows. Based on experimental design, each treatment was assigned randomly to the experimental units within a block. The species were sown according to their recommended seeding rates: 25 kg/ha for *Vicia villosa*, *Vicia dasycarpa* and *Vicia atropurpurea*; 30 kg/ha for *Vicia sativa* and 75 kg/ha for *Vicia narbonensis*. At sowing, 100 kg/ha diammonium phosphate fertilizer was uniformly applied for all treatments at both locations. The first hand weeding was made thirty days after crop emergence and the second weeding was done thirty days after the first weeding. The two rows next to the guard rows were used for determination of number of pods per plant, pod length per plant and number of seeds per pod. Similarly, the two rows prior to the inner two rows were used to evaluate proportion of morphological fractions, forage and morphological fraction yields and forage quality. The remaining two rows were used for seed yield determination. Generally, maximum cares were taken in the experimental plots to reduce the possible yield limiting factors which could affect the performance of vetch species.

Table1: Accessions of five vetch species used as treatments for the experiment

No	Species	Accessions	No	Species	Accessions
1	*Vicia sativa*	64266	11	*Vicia villosa*	2434
2	*Vicia sativa*	61904	12	*Vicia villosa*	2446
3	*Vicia sativa*	61744	13	*Vicia narbonensis*	2384
4	*Vicia sativa*	61509	14	*Vicia narbonensis*	2387
5	*Vicia sativa*	61039	15	*Vicia narbonensis*	2376
6	*Vicia sativa*	61212	16	*Vicia narbonensis*	2392
7	*Vicia villosa*	2565	17	*Vicia narbonensis*	2380
8	*Vicia villosa*	2450	18	*Vicia dasycarpa*	Namoi
9	*Vicia villosa*	2424	19	*Vicia dasycarpa*	Lana
10	*Vicia villosa*	2438	20	*Vicia atropurpurea*	Atropurpurea

Data Collection

Description of data collection procedure is presented in Table 2. Data on morpho-agronomic traits for vetch species and their accessions were collected on plot and plant basis according to Getnet (Getnet, 1999).

Table 2: Descriptions of morpho-agronomic and quality traits of vetch species and their accessions

SN	Traits	Descriptions
1	Days to forage harvesting (days)	Counted from days to emergence to days of half (50%) of the plot/plants set flower.
2	Days to seed harvesting (days)	Counted from days to emergence to days to seed maturity.
3	Plant height (cm)	Measured from the ground to the tip of plant at forage harvesting stage.
4	Biomass production rate (kg ha^{-1} day^{-1})	Computed by dividing the above ground biomass yield to the number of days to forage harvesting.
5	Forage dry matter yield (t/ha)	Determined by converting the harvested fresh biomass yield in to dry matter yield after oven drying for 24 hours at a temperature of 105 ^{o}C.
6	Crude protein yield (t/ha)	Computed by multiplying forage dry matter yield (t/ha) with crude protein content (%) and then divided by 100%
7	Leaf fraction (%)	Computed as the ratio of leaf dry biomass fraction to total dry biomass and multiplied by 100 percent.
8	Stem fraction (%)	Computed as the ratio of stem dry biomass fraction to total dry biomass and multiplied by 100 percent.
9	Leaf to stem ratio	Computed as the ratio of leaf dry matter to stem dry matter.
10	Grain filling period (days)	Counted from days to flower initiation to days to physiological maturity.
11	Grain sink filling rate (kg ha^{-1} day^{-1})	Computed as the ratio of grain yield to number of days from flower initiation to physiological maturity.
12	Number of pods per plant (number)	Counted by uprooting six plants from each experimental plot.
13	Pod length (cm)	Measured the length by taking six pods per plant.
14	Number of seeds per pod (number)	Counted the seeds by taking six pods per plant from each plot.
15	Grain yield (t/ha)	The plants harvested from ground level at the optimum seed harvesting time and oven dried at 100°c for 48 hours to adjust the moisture content to the level of 10%.
16	Thousand seed weight (gm)	Thousand seeds counted and oven dried at100°c for 48 hours to determine the weight

Chemical Analysis and *In-vitro* Dry Matter Digestibility

The oven dried samples were ground to pass through a 1 mm sieve size for laboratory analysis. Before scanning, the samples were dried at 60°C overnight in an oven to standardize the moisture and then 3 g of each sample was scanned by the Near Infra Red Spectroscopy (NIRS) with an 8 nm step. The samples were analyzed in % DM basis for Ash, crude protein (CP), Neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and *in-vitro* dry matter digestibility (IVDMD) using a calibrated NIRS (Foss 5000 apparatus and Win ISI II software). This is one of the recent techniques that uses a source of producing light of known wavelength pattern (usually 800- 2500 nm) and that enables to obtain a complete picture of the organic composition of the analyzed substance/materials (Van Kempen, 2001). It is now recognized as a valuable tool in the accurate determination of the chemical composition, digestibility parameters and gas production parameters of a wide range of forages (Herrero *et al*., 1997). The cellulose content was computed by subtracting the acid detergent lignin from acid detergent fiber, while the hemicelluloses content was computed by subtracting the acid detergent fiber from neutral detergent fiber.

Statistical Analysis

Analysis of variance procedures of SAS general linear model was used to compare treatment means (SAS, 2002). The F-test for homogeneity of variance was carried and its value was computed as the ratio of the two error mean squares; the larger error mean square in the numerator and the smaller error mean square in the denominator (Gomez and Gomez, 1984). According to Gomez and Gomez (1984), the error variances could be considered homogeneous when the error mean square ratio was not greater than the tabulated F-value. Logarithmic, square root and arcsine (angular) transformations were used for data which couldn't exhibit homogeneity of variance for agro-morphological and quality parameters according to Gomez and Gomez (1984). Duncan multiple range test at 5% significance was used for comparison of means. The data was analyzed using the following model: $\mathbf{Y_{ijk} = \mu + T_i + L_j + (TL)_{ij} + B_{k(j)} + e_{ijk}}$, Where, $\mathbf{Y_{ijk}}$ = measured response of treatment i in the block k of location j, $\mathbf{\mu}$ = grand mean, $\mathbf{T_i}$ = effect of treatment i, $\mathbf{L_j}$ = effect of location j, **TL**= treatment and location interaction, $\mathbf{B_{k(j)}}$ = effect of block k in location j and $\mathbf{e_{ijk}}$ = random error effect of treatment i in block k of location j. Moreover, the Pearson correlation analysis procedure of the SAS statistical package was also applied to measure the strength of linear dependence between two measured variables.

Results and Discussion

Forage Chemical Compositions and *In-vitro* Dry Matter Digestibility

Most measured nutritional traits of vetch species and their accessions were comparatively higher at Holetta than Ginchi during the growing season. The nutritional qualities of any feed can be influenced by genetic, environmental and their interactions. Getnet and Ledin (2001) found that forage quality of the biomass was generally affected by sowing method, fertilizer and location (soil type). The ash content of vetch species in this study showed significant (P<0.05) difference at both locations, ranging from 7.7 to 10.4% with a mean of 8.8% and from 6.7 to 9.5% with a mean of 8.3% at Holetta and Ginchi, respectively (Table 3). The average ash content was highest in *Vicia dasycarpa,* and the lowest in *Vicia sativa* at both locations. The higher ash content in *Vicia dasycarpa* could be an indication of high mineral concentration. Intermediate to late maturing vetch species had relatively higher ash content than early maturing species, which could be due to differences in proportions and composition of morphological fractions. Fekede (2004) also reported that late maturing or low grain producing oats varieties had comparatively higher ash content in their whole forage DM than early maturing or high grain producing oats varieties. On the other hand, the ash content was also different (P<0.05) among the accessions at both locations (Table 4). The result revealed that Lana (*V. dasycarpa*) had comparatively higher, whereas accession 61212 (*V. sativa*) lower in ash content at both locations. Early maturing accession 61039 (*V. sativa*) had lower ash content at both locations, whereas *Vicia narbonensis* accessions such as 2380 at Holetta and 2392 at Ginchi had relatively higher ash content from early maturing vetch accessions. In addition to higher CP content, herbaceous forage legumes have higher content of some minerals like calcium, sulfur and possibly phosphorus than grasses, and well nodulated legumes contain large amount of calcium, magnesium and other essential elements (Jennings, 2004). The ash content of vetch species was found to be higher at Ginchi in this study and might be attributed to variations in climatic conditions and soil characteristics. Concentration of minerals in forage varies due to factors like plant developmental stage, morphological fractions, climatic conditions, soil characteristics and fertilization regime (Jukenvicius, 2007).

The CP content also showed significant (P<0.05) difference among vetch species at both locations (Table 3). The CP content of the species at forage harvesting stage ranged from 18.9 to 25.8% with a mean of 22.4% and from 18.9 to 26.0% with a mean of 22.5% at Holetta and Ginchi, respectively. *Vicia dasycarpa* had higher (P<0.05) CP content followed by *Vicia atropurpurea*, *Vicia narbonensis, Vicia villosa* and *Vicia sativa* at both locations. Getnet and Ledin (2001) reported that vetch has a higher CP content compared to many other tropical herbaceous legumes. They found that the CP content of vetch was 18.9%, which is similar to good alfalfa forage. Most of the herbaceous legumes have CP content of >15%, a level which is usually required to support lactation and growth, which suggests the adequacy of herbaceous legumes to supplement basal diets of predominately low quality pasture and crop residues (Norton, 1982). The result in this study indicated that intermediate maturing species such as *Vicia dasycarpa* and *Vicia atropurpurea* had comparatively higher CP content whereas early and late maturing species such as *Vicia sativa*, *Vicia narbonensis* and *Vicia villosa* had comparatively lower CP content at both locations. It has also been observed that CP content was different (P<0.05) among the accessions at both locations (Table 4). Lana and Naomi had higher (P<0.05) CP content, whereas all *Vicia sativa* accessions had lower (P<0.05) CP content at both locations. Lana (*V. dasycarpa*) and accession 61039 (*V. sativa*) gave the highest and lowest CP content at both locations, respectively. Legumes confer several advantages in the context of animal nutrition; their higher protein content relative to that of grasses has long been recognized (Getnet and Ledin, 2001), and provide quality feed for livestock due to higher CP content (Ikwuegbu *et al*., 1996). Legumes in general and vetch in particular are excellent sources of N for livestock feed (Seyoum, 1994), vetch has a higher CP content compared to many other tropical herbaceous legumes (Diriba *et al*., 2003), the importance of forage legumes in livestock and crop production is well recognized (Getnet, 1999).

The *in-vitro* dry matter digestibility (IVDMD) was not statistically different, when the two locations mean Holetta (66.5%) and Ginchi (66.3%) compared, but the species were significantly different at both locations (Table 3). The IVDMD ranged from 60.47 to 73.39% with a mean of 66.47% and from 60.33 to 73.22% with a mean of 66.31% at Holetta and Ginchi, respectively. At both locations, IVDMD of *Vicia dasycarpa* was the highest (P<0.05), while *Vicia sativa* was the lowest. The IVDMD values greater than 65% indicates good feeding value (Mugeriwa *et al*., 1973) and values below this threshold level result in reduced intake due to lowered digestibility. The IVDMD values observed in this study were above this threshold level for all vetch species except *Vicia sativa* at both locations, which result in higher voluntary intake and digestibility and this result also supported by Getnet and Ledin (2001). The IVDMD is positively correlated to the CP content and inversely related to the fiber content (NDF and ADF) and cell walls constituents (ADL, cellulose and hemi cellulose) for most vetch species. On the other hand, the IVDMD of vetch accessions also showed significant (P<0.05) difference at both locations (Table 4). The highest and lowest IVDMD was recorded for Lana (*V. dasycarpa*) and accession 61212 (*V. sativa*) at both locations, respectively. It was generally observed that early maturing vetch species and their accessions had lower IVDMD compared to intermediate to late maturing vetch species and their accessions. This could be due to the presence of higher fiber and cell wall constituents, and lower CP content in early maturing vetch species and their accessions than intermediate to late maturing species and their accessions. The IVDMD of any forage crop varied with harvesting stage (Tessema *et al*., 2002); fiber and cell wall constituents (Mustafa *et al*., 2000); proportions of morphological fractions (McDonald *et al*., 1995); soil, plant species and climate (McDowell, 2003). Temperature is among the environmental factors that have a direct influence on forage quality. A rise in temperature increases cell wall constituents, increase lignifications, decrease soluble carbohydrate concentration and decrease digestibility (Pearson and Ison, 1997). It also reduces the leaf to stem ratio of forage, which directly affects the digestibility of the forage dry matter because of the lower digestibility of the stems in relation to the leaf (Buxton *et al*., 1995).

Table 3: Least square means for ash and CP (%) on DM basis and CP yield (t ha^{-1})

	Ash		CP▲		IVDMD	
Species	**Holetta**	**Ginchi**	**Holetta**	**Ginchi**	**Holetta**	**Ginchi**
Vicia sativa	7.7^{c}	6.7^{d}	18.9^{e}	18.9^{e}	60.47^{e}	60.33^{e}
Vicia villosa	9.0^{b}	7.9^{c}	21.4^{d}	21.6^{d}	66.41^{c}	66.21^{c}
Vicia narbonensis	8.2^{c}	9.0^{ab}	22.4^{c}	22.4^{c}	66.54^{b}	66.37^{b}
Vicia dasycarpa	10.4^{a}	9.5^{a}	25.8^{a}	26.0^{a}	73.39^{a}	73.22^{a}
Vicia atropurpurea	8.7^{bc}	8.3^{bc}	23.4^{b}	23.6^{b}	65.56^{d}	65.45^{d}
Mean	8.8	8.3	22.4	22.5	66.47	66.31
CV (%)	10.01	9.76	0.61	0.95	0.15	0.14
R^2	0.51	0.65	0.99	0.97	1.00	1.00

▲ = Square root transformation; Means followed by a common superscript letters with in a column are not significantly different from each other at P<0.05; CP- Crude protein; CP yield – Crude protein yield (t ha^{-1}); CV-Coefficient of variation.

Table 4: Average ash and CP (%) on DM basis and CP yield (t ha^{-1}) of twenty accessions

		Ash		CP▲		IVDMD	
Species	**Accessions**	**Holetta**	**Ginchi**	**Holetta**	**Holetta**	**Ginchi**	**Holetta**
Vicia sativa	64266	7.9^{cdef}	6.5^{fg}	18.8^{gh}	19.1^{e}	60.49^{fg}	60.33^{hi}
V. sativa	61904	7.4^{ef}	6.5^{fg}	19.0^{g}	19.1^{e}	60.44^{fg}	60.29^{i}
V. sativa	61744	7.8^{def}	6.7^{efg}	19.0^{gh}	18.9^{e}	60.49^{fg}	60.30^{hi}
V. sativa	61509	7.6^{def}	7.4^{cdef}	19.0^{g}	18.9^{e}	60.48^{fg}	60.42^{gh}
V. sativa	61039	8.4^{bcdef}	7.8^{bcdef}	18.6^{h}	18.2^{f}	60.56^{f}	60.50^{g}
V. sativa	61212	6.9^{f}	5.6^{g}	19.0^{g}	19.1^{e}	60.38^{g}	60.16^{j}
V. villosa	2565	8.9^{bcde}	7.7^{bcdef}	21.3^{f}	21.5^{d}	66.37^{cd}	66.17^{e}
V. villosa	2450	9.2^{bcd}	7.2^{def}	21.9^{e}	22.3^{c}	66.44^{cd}	66.18^{e}
V. villosa	2424	9.0^{bcde}	8.3^{abcd}	21.4^{f}	21.4^{d}	66.44^{cd}	66.29^{cde}
V. villosa	2438	8.6^{bcde}	7.9^{bcde}	21.4^{f}	21.5^{d}	66.34^{d}	66.19^{de}
V. villosa	2434	9.2^{bcd}	7.9^{bcde}	21.4^{f}	21.2^{d}	66.39^{cd}	66.19^{de}
V. villosa	2446	9.5^{abc}	8.2^{abcd}	21.4^{f}	21.5^{d}	66.46^{cd}	66.23^{de}
V. narbonensis	2384	7.9^{cdef}	8.6^{abc}	22.5^{cd}	22.3^{c}	66.50^{bcd}	66.38^{bc}
V. narbonensis	2387	8.4^{bcdef}	8.8^{ab}	22.6^{c}	22.4^{c}	66.50^{bcd}	66.36^{bc}
V. narbonensis	2376	7.8^{def}	8.9^{ab}	22.3^{cde}	22.3^{c}	66.54^{bc}	66.38^{bc}
V. narbonensis	2392	7.7^{def}	9.5^{a}	22.5^{cd}	22.5^{c}	66.51^{bcd}	66.43^{b}
V. narbonensis	2380	9.2^{bcd}	9.0^{ab}	22.1^{de}	22.2^{c}	66.64^{b}	66.31^{bcd}
V. dasycarpa	Namoi	9.8^{ab}	9.4^{a}	25.8^{a}	26.0^{a}	73.31^{a}	73.18^{a}
V. dasycarpa	Lana	10.9^{a}	9.5^{a}	25.8^{a}	26.0^{a}	73.46^{a}	73.25^{a}
V. atropurpurea	atropurpurea	8.7^{bcde}	8.3^{abcd}	23.4^{b}	23.6^{b}	65.56^{e}	65.45^{f}
	Mean	8.5	8.0	21.5	21.5	65.31	65.15
	CV (%)	9.82	9.04	0.55	0.80	0.14	0.11
	R^2	0.66	0.78	0.99	0.98	1.00	1.00

▲ = Square root transformation; Means followed by a common superscript letters with in a column are not significantly different from each other at P<0.05; CP- Crude protein; CP yield – Crude protein yield (t ha^{-1}); CV-Coefficient of variation.

The NDF content of vetch species differed significantly (P<0.05) at both locations, which ranged from 36.5 to 55.2% with a mean of 48.5% and from 39.5 to 54.3% with a mean of 43.8% at Holetta and Ginchi, respectively (Table 5). *Vicia sativa* had higher (P<0.05) NDF content than *Vicia dasycarpa* and *Vicia atropurpurea* at Holetta, whereas *Vicia narbonensis* had the highest (P<0.05) NDF content at Ginchi. The NDF contents above the critical value of 60% result in decreased voluntary feed intake, feed conversion efficiency and longer rumination time (Meissner *et al*., 1991). However, the NDF content of all vetch species tested was found below this threshold level which indicates higher digestibility. As stems mature, protein content decreases and carbohydrate content increases (Dien *et al*., 2006) and at maturity, stems make up as much as 80% of the total DM and NDF, which generally estimates the percentage of total fiber (cellulose, hemicelluloses and lignin) increases due to increases in xylem tissue (Jung and Engels, 2002). However, a high amount of protein is associated with NDF, increasing the ruminal and total tract digestibility (Mustafa *et al*., 2000). There were significant variations (P<0.05) among all tested accessions of vetch species at both locations, in which accession 61039 (*V. sativa*) and atropurpurea (*V. atropurpurea*) variety at Holetta and accession 2387 (*V. narbonensis*) and Namoi (*V. dasycarpa*) variety at Ginchi had comparatively higher and lower NDF content, respectively (Table 6). Early maturing and erect growing type of vetch species had comparatively higher NDF content than intermediate to late maturing and creeping type of vetch species. The nutrient composition of forage crops is variable depending on many factors such as genotypic characteristics, environmental conditions and harvesting stages of the plants (Rotili *et al*., 2001). High temperature and low rainfall tend to increase cell wall polysaccharides and then decrease the soluble carbohydrates (Pascual *et al*., 2000). There was a significant increase in NDF, ADF and ADL in plants with increased maturity (Kallenbach *et al*., 2002). Digestibility decreased with advancing age. This decline resulted from the interaction of factors such as increased fiber concentration in plant tissue, increased lignifications during plant development and decreased leaf to stem ratio. Increasing dietary NDF concentration most often has a negative impact on the amount of DM consumed by lactating dairy cows, which generally translates into reduced milk production (Allen, 2000). However, legume fibers ferment more rapidly in the rumen that is why ruminants can consume larger amounts of legumes than grasses (Hinders, 1995).

The acid detergent fiber (ADF) and acid detergent lignin (ADL) contents of vetch species significantly ($P<0.05$) differed at both locations (Table 5). The ADF content ranged from 22.7 to 38.1% with a mean of 33.2% and from 24.7 to 32.6% with a mean of 28.5% at Holetta and Ginchi, respectively. The result revealed that *Vicia narbonensis* and *Vicia villosa* had the highest ADF content at Holetta and Ginchi, respectively. On the other hand, *Vicia atropurpurea* and *Vicia narbonensis* had the lowest ADF content at Holetta and Ginchi, respectively. The ADL content ranged from 8.5 to 13.7% with a mean of 11.0% and from 6.4 to 9.1% with a mean of 8.2% at Holetta and Ginchi, respectively. The result indicated that *Vicia narbonensis* (13.7%) and *Vicia dasycarpa* (9.1%) gave the highest ADL content at Holetta and Ginchi, respectively, whereas *Vicia atropurpurea* and *Vicia sativa* gave the lowest ADL content at Holetta and Ginchi, respectively. The ADF and ADL contents showed significant ($P<0.05$) variations among the tested accessions at both locations (Table 6). The ADF and ADL contents were higher in accessions 2384 (*V. narbonensis*) and 2565 (*V. villosa*) at Holetta and Ginchi, respectively. Fiber is the structural part of plants, namely, components of the cell wall: soluble pectins, waxes, and proteins, and insoluble lignin, cellulose, and hemicelluloses contents and it is important for determining quality within the parameter of digestibility (Van Soest, 1994). Lignin is a component which attributes erectivety, strength and resistance to plant tissue thereby limiting the ability of rumen microorganisms to digest the cell wall contents (Reed *et al*., 1988). The presence of insoluble fiber, particularly lignin, lowers the overall digestibility of the feed by limiting nutrient availability (Holechek *et al*., 2004).

Table 5: Least square means for NDF, ADF and ADL (%) on DM basis of five vetch species

	NDF▲		ADF		ADL▲	
Species	**Holetta**	**Ginchi**	**Holetta**	**Ginchi**	**Holetta**	**Ginchi**
Vicia sativa	55.2^{a}	39.5^{b}	35.4^{a}	29.3^{bc}	10.7^{b}	7.6^{a}
Vicia villosa	51.6^{ab}	43.9^{b}	35.3^{a}	32.6^{a}	11.4^{ab}	9.1^{a}
Vicia narbonensis	54.4^{a}	54.3^{a}	38.1^{a}	23.8^{d}	13.7^{a}	6.4^{b}
Vicia dasycarpa	44.7^{bc}	39.7^{b}	34.5^{a}	32.8^{ab}	10.9^{ab}	9.1^{a}
Vicia atropurpurea	36.5^{c}	41.7^{b}	22.7^{b}	24.7^{cd}	8.5^{b}	8.8^{a}
Mean	48.5	43.8	33.2	28.5	11.0	8.2
CV (%)	7.79	12.35	13.9	14.86	14.28	13.12
R^2	0.42	0.24	0.47	0.53	0.36	0.41

▲ = Square root transformation; Means followed by a common superscript letters with in a column are not significantly different from each other at $P<0.05$; NDF- Neutral Detergent Fiber, ADF- Acid Detergent Fiber, ADL- Acid Detergent Lignin.

Table 6: Average NDF, ADF and ADL contents on (%) DM basis of twenty vetch accessions

Species	Accessions	NDF▲		ADF		ADL	
		Holetta	Ginchi	Holetta	Holetta	Ginchi	Holetta
Vicia sativa	64266	50.1abc	37.0bc	28.4de	30.5abcd	7.5e	7.2bcd
V. sativa	61904	60.4a	35.3c	39.9abc	29.5abcd	13.0abcd	7.5abcd
V. sativa	61744	53.8abc	41.2bc	36.1abcd	27.4bcde	10.6cde	6.0cd
V. sativa	61509	57.2ab	42.5abc	36.8abcd	27.2bcde	11.4abcde	9.3abc
V. sativa	61039	60.4ab	45.4abc	35.6abcd	28.1abcde	11.2bcde	7.3abcd
V. sativa	61212	49.0abcd	35.8c	35.4abcd	32.9abc	10.4cde	8.5abcd
V. villosa	2565	49.5abcd	46.2abc	35.4abcd	36.4a	11.7abcde	10.9a
V. villosa	2450	55.2ab	56.7abc	32.0cd	32.5abc	9.1de	8.0abcd
V. villosa	2424	53.5abc	41.3bc	37.1abcd	32.4abc	12.7abcd	9.3abc
V. villosa	2438	51.3abc	37.5bc	36.9abcd	29.6abcd	12.0abcde	8.5abcd
V. villosa	2434	44.6bcd	39.2bc	33.4bcd	32.5abc	10.5cde	9.0abc
V. villosa	2446	55.7ab	42.6bc	36.9abcd	31.9abc	12.5abcd	8.8abc
V. narbonensis	2384	51.0abc	46.8abc	42.9a	25.0cde	15.9a	7.2bcd
V. narbonensis	2387	55.7ab	64.8a	33.3bcd	22.4cde	9.9cde	5.0d
V. narbonensis	2376	60.2a	46.4abc	41.2ab	25.2cde	15.7ab	7.2bcd
V. narbonensis	2392	50.7abc	58.3ab	35.0abcd	26.4bcde	13.1abcd	7.4abcd
V. narbonensis	2380	54.2abc	55.2abc	38.2abc	19.9e	13.8abc	5.0d
V. dasycarpa	Namoi	39.9cd	34.7c	34.2abcd	29.8abcd	10.5cde	7.9abcd
V. dasycarpa	Lana	49.5abcd	44.7abc	34.9abcd	34.7ab	11.3abcde	10.3ab
V. atropurpurea	atropurpurea	36.5d	41.7bc	22.7e	24.7cde	8.5de	8.8abc
	Mean	51.9	44.6	35.3	29.0	11.6	8.0
	CV (%)	7.76	12.28	12.99	15.02	20.44	22.9
	R^2	0.59	0.46	0.67	0.66	0.67	0.62

▲ = Square root transformation; Means followed by a common superscript letters with in a column are not significantly different from each other at P<0.05; NDF- Neutral Detergent Fiber, ADF- Acid Detergent Fiber, ADL- Acid Detergent Lignin.

Correlations between Agro-Morphological Traits

The linear correlation coefficients between observed agro-morphological traits are shown in Table 7. Days to forage harvest showed a strong (P<0.001) positive correlation with days to seed harvest (r= 0.95), plant height at forage harvest (r= 0.94), forage DM yield (r= 0.85), but negatively correlated (P<0.001) with leaf to stem ratio (r= -0.80) and thousand seed weight (r= -0.82). It was also negatively correlated (P>0.05) with biomass production rate (r= -0.39) and seed yield (r= -0.26). According to Parmer *et al*., (2003) days to forage harvesting also positively correlated with plant height in cowpea. Fekede (2004) also reported that days to maturity of forage correlated positively with plant height, herbage yield, but negatively correlated with seed yield and thousand seed weight. Other research findings also indicated that days to forage harvesting and plant height correlated negatively with seed yield in cowpea (Oseni *et al*., 1992). Early maturing vetch accessions had shorter plant height; faster biomass production and grain sink filling rates; higher leaf to stem ratio, seed yield and thousand seed weight; lower DM yield, and shorter grain filling period than late maturing accessions of vetch species. Plant height at forage harvest showed a significant (P<0.001) positive correlation with forage DM yield (r= 0.86), and stem proportion (r= 0.35; P>0.05). It was negatively (P<0.001) correlated with leaf to stem ratio (r= -0.95), thousand seed weight (r= -0.79), biomass production rate (r= -0.40; P>0.05), and seed yield (r= -0.26; P>0.05). Fekede (2004) also reported that plant height at forage harvest was positively and significantly correlated with herbage yield, whereas it was negatively correlated with grain yield and thousand seed weight of oats varieties. Taller vetch accessions had lower leaf to stem ratio, thousand seed weight and seed yield; higher DM yield; longer grain filling period and slower biomass production rate and grain sink filling rate than shorter accessions of vetch species. Getnet *et al*., (2003) also reported that taller and late maturing oats varieties had higher forage yield but lower grain yield.

Biomass production rate showed a non significant (P>0.05) correlation with leaf to stem ratio (r= 0.32), thousand seed weight (r= 0.25), and seed yield (r= 0.40). Forage DM yield had weak negative correlation (r= -0.14; P>0.05) with biomass production rate. It was observed that fast growing accessions had higher leaf to stem ratio, grain sink filling rate, thousand seed weight and seed yield but lower forage DM yield and shorter grain filing period than slow growing ones. Forage DM yield had a significant positive correlation with grain filling period (r= 0.47; P<0.05) and number of pods per plant (r= 0.68; P<0.01). On the other hand, it was significantly and negatively correlated with pod length (r= -0.60; P<0.01) and thousand seed weight (r= -0.91; P<0.001). Grain sink filling rate, number of seeds per pod, and seed yield had non-significant negative correlation coefficient of r= -0.40, r= -0.02, and r= -0.16 with forage DM yield, respectively. High forage DM yielder accessions were late maturing and had high number of pods per plant but lower in pod length, number of seeds per pod, thousand seed weight and seed yield.

Grain filling period was significantly (P<0.01) and positively correlated with number of pods per plant (r= 0.68). It was also significantly and negatively correlated with pod length (r= -0.68; P<0.01), number of seeds per pod (r= -0.61; P<0.01), but non-significant with grain sink filling rate (r= -0.22), thousand seed weight (r= -0.39), and seed yield (r= - 0.03). Grain sink filling rate showed a significant positive correlation with pod length (r= 0.57; P<0.01), seed yield (r= 0.96; P<0.001), and non-significant with number of seeds per pod (r= 0.31), and thousand seed weight (r= 0.43), but a significant inverse relation with number of pods per plant (r= -0.49; P<0.05). Grain filling period inversely related with grain sink filling rate and late maturing accessions had negative effect on seed yield and its related performance but positive effect on number of pods per plant due to higher number of branches or tillers. Number of pods per plant was significantly and negatively correlated with pod length (r= -0.96; P<0.001), number of seeds per pod (r= - 0.66; P<0.001), thousand seed weight (r= -0.66; P<0.01) and had non-significant negative correlation with seed yield (r= -0.27). Pod length was significantly (P<0.01) and positively correlated with number of seeds per pod (r= 0.74), and thousand seed weight (r= 0.58), but not significantly correlated with seed yield (r= 0.39). Number of seeds per pod was not significantly and positively correlated with seed yield (r= 0.24) but negatively correlated with thousand seed weight (r= -0.08). According to Anbumalarmathi *et al*., (2005) pod length, number of seeds per pod and thousand seed weight also positively correlated with seed yield in cowpea. Other research findings also indicated that thousand seed weight negatively correlated with days to forage harvesting (Singh and Verma, 2002), number of pods per plant (Rahul *et al*., 2003) and number of seeds per pod (Kalaiyarasi and Palanisamy, 1999) in cowpea. Negative and significant association of seed yield were observed with days to seed harvest in narbon vetch (Siddique *et al*., 1996) and plant height in common vetch. Seed yield has been reported to be influenced by the number of pods per plant, number of seeds per pod and thousand seed weight in faba bean (Nigem *et al*., 1990); number of pods per plant and number of seeds per pod in common vetch; and number of pods per plant in mung bean (Kumar *et al*., 2002).

Table 7: Correlation coefficients (r) between agro-morphological traits of accessions of vetch species grown in the central highlands of Ethiopia

Traits	DFH	DSH	PHFH	BPR	LF	SF	LSR	FDMY	GFP	GSFR	NPP	PL	NSP	TSW
DSH	0.95***													
PHFH	0.94***	0.92***												
BPR	-0.39	-0.18	-0.40											
LP	-0.23	-0.23	-0.37	0.50*										
SP	0.30	0.30	0.35	-0.17	-0.81***									
LSR	-0.80***	-0.91***	-0.95***	0.32	0.30	-0.28								
FDMY	0.85***	0.83***	0.86***	-0.14	-0.13	0.17	-0.80***							
GFP	0.56**	0.79***	0.57**	-0.17	-0.03	0.21	-0.63**	0.47*						
GSFR	-0.49*	-0.42	-0.49*	0.39	0.48*	-0.33	0.35	-0.40	-0.22					
NPP	0.89***	0.91***	0.94***	-0.39	-0.37	0.37	-0.94***	0.70**	0.68**	-0.49*				
PL	-0.87***	-0.87***	-0.88***	0.47*	0.39	-0.39	0.86***	-0.60**	-0.68**	0.57**	-0.96***			
NSP	-0.39	-0.49*	-0.46*	0.24	0.28	-0.26	0.52*	-0.02	-0.61**	0.31	-0.66**	0.74**		
TSW	-0.82***	-0.76**	-0.79***	0.25	0.28	-0.37	0.69**	-0.91***	-0.39	0.43	-0.66**	0.58**	-0.08	
SY	-0.26	-0.16	-0.26	0.40	0.46*	-0.28	0.12	-0.16	-0.03	0.96***	-0.27	0.39	0.24	0.21

*P<0.05; **P<0.01; ***P<0.001; DFH= days to forage harvesting; DSH= days to seed harvesting; PHFH= plant height at forage harvesting; BPR= biomass production rate; LSR= leaf to stem ratio; FDMY= forage dry matter yield; GFP= grain filling period; GSFR= grain sink filling rate; NPP= number of pods per plant; PL= pod length; NSP= number of seeds per pod; TSW= thousand seed weight; SY= seed yield

Correlations between Nutritional Traits

The linear correlation coefficients between nutritional traits are shown in Table 8. The ash content showed a significant (P<0.001) positive correlation with CP content (r= 0.86) and IVDMD (r= 0.91). But, it was weakly and positively correlated (P>0.05) with CP yield (r= 0.11), NDF content (r= 0.07), ADL content (r= 0.23), and hemicelluloses content (r= 0.09). According to Diriba *et al*. (2003), ash was positively correlated with CP, NDF and ADF, but poorly and negatively associated with lignin, cellulose and hemicelluloses contents. The CP content showed a significant (P<0.001) positive correlation with IVDMD (r= 0.96), but non-significant positive correlation with CP yield (r= 0.13), and ADL content (r= 0.18). It was not significantly and inversely correlated with NDF content (r= -0.11), ADF content (r= -0.12), cellulose content (r= -0.25), and hemicelluloses content (r= -0.05). Significant but negative correlations were found between IVDMD and cell wall components, and IVDMD and CP were significantly and positively correlated (Tessema *et al*., 2002). Tessema *et al*., (2002) also reported that CP, calcium and phosphorus showed highly positive correlations with IVDMD, whereas NDF, ADF, ADL and cellulose showed negative correlations with IVDMD in Napier grass harvested at different heights.

The NDF content was significantly (P<0.001) and positively correlated with hemicelluloses (r= 0.90), but had very weak and non significant negative correlation with ADF (r= -0.03), ADL (r= -0.01), cellulose (r= -0.04) contents and IVDMD (r= -0.09). Paterson *et al*., (1994) also reported that NDF content is negatively correlated with voluntary intake of forage DM. The ADF content showed a significant positive correlation with ADL content (r= 0.69; P<0.01), cellulose content (r= 0.91; P<0.001) and IVDMD (r= 0.08), but significantly (P<0.05) and negatively correlated with hemicelluloses content (r= -0.47). Hassan and Osman (1984) also reported that ADF showed positive correlations with ADL, cellulose and negative correlations with cell wall components and hemicelluloses. Both cellulose and hemicelluloses contents had a non-significant negative correlation coefficients of r= -0.05 and r= -0.11 with IVDMD, respectively. Cellulose content also inversely related with hemicelluloses content (r= -0.43). Fekede (2004) also reported that Oats varieties had negative but non-significant correlation between cellulose and hemicelluloses contents.

Table 8: Correlation coefficients (r) between nutritional traits of accessions of vetch species grown in the central highlands of Ethiopia

Traits	Ash	CP	CPY	NDF	ADF	ADL	IVDMD	Cellulose
CP	0.86***							
CPY	0.11	0.13						
NDF	0.07	-0.11	-0.59**					
ADF	-0.06	-0.12	0.17	-0.03				
ADL	0.23	0.18	-0.03	-0.01	0.69**			
IVDMD	0.91***	0.96***	0.16	-0.09	0.08	0.28		
Cellulose	-0.21	-0.25	0.24	-0.04	0.91***	0.33	-0.05	
Hemicelluloses	0.09	-0.05	-0.60**	0.90***	-0.47*	-0.31	-0.11	-0.43

*P<0.05; **P<0.01; ***P<0.001; CP- Crude protein; CPY- Crude protein yield; NDF- Neutral detergent fiber; ADF- Acid detergent fiber; ADL- Acid detergent lignin; IVDMD- *In- vitro* dry matter digestibility.

Correlations between Agro-Morphological and Nutritional Traits

The linear correlation coefficients between agro-morphological and nutritional traits are shown in Table 9. The CP content was positively correlated with days to forage harvest (r= 0.09), plant height at forage harvest (r= 0.28), the proportion of stem (r= 0.31), forage DM yield (r= 0.19), and grain filling period (r= 0.10). It was also negatively correlated with biomass production rate (r= -0.45; P<0.05), the proportion of leaf (r= -0.47; P<0.05), leaf to stem ratio (r= -0.32) and seed yield (r= -0.30). Fekede (2004) also reported that CP content had low degree of negative correlation with the proportion of leaf blade and leaf to stem ratio in oats varieties. Intermediate to late maturing accessions of vetch species had comparatively higher CP content than early maturing ones. The CP yield showed a significant (P<0.001) positive correlation with days to forage harvest (r= 0.81), plant height at forage harvest (r= 0.84), and forage DM yield (r= 0.83). The proportion of stem and grain filling period had a positive correlation coefficients of r= 0.30 and r= 0.41 with CP yield, respectively. On the other hand, CP yield was negatively correlated with biomass production rate (r= -0.46; P<0.05), leaf to stem ratio (r= -0.80; P<0.001), the proportion of leaf (r= -0.33) and seed yield (r= -0.27). Early maturing accessions had comparatively lower CP yield than intermediate to late maturing ones.

The NDF content showed a significant positive correlation with biomass production rate (r= 0.44; P<0.05), leaf to stem ratio (r= 0.56; P<0.01), and seed yield (r= 0.05). It had a significant (P<0.05) negative correlation with days to forage harvest (r= -0.55), plant height at forage harvest (r= -0.62), and forage DM yield (r= -0.53). Intermediate to late maturing accessions had comparatively lower NDF content than early maturing accessions of vetch species. The ADF content showed a weak positive correlation (P>0.05) with days to forage harvest (r= 0.16), plant height at forage harvest (r= 0.17), biomass production rate (r= 0.13), the proportion of stem (r= 0.06), forage DM yield (r= 0.21), grain filling period (r= 0.32), but inversely related with the proportion of leaf (r= -0.20), leaf to stem ratio (r= -0.24), and seed yield (r= -0.17). Early maturing accessions had comparatively lower ADF content than intermediate to late maturing ones. The IVDMD had a positive correlation with days to forage harvest (r= 0.17), plant height at forage harvest (r= 0.31), forage DM yield (r= 0.10), and grain filling period (r= 0.24), but negatively correlated with biomass production rate (r= -0.37), the proportion of leaf (r= -0.40), leaf to stem ratio (r= -0.41), and seed yield (r= -0.31). Early maturing accessions had higher biomass production rate, leaf proportion, leaf to stem ratio, and seed yield, but lower IVDMD than intermediate to late maturing ones. This could be due to higher CP and lower fiber in the latter than the former.

Some correlations indicated in this study did not follow the normal trend due to the differences in agro-morphological and nutritional traits in vetch species. Most research results indicate that proportion of leaf and leaf to stem ratio are positively correlated with CP content and IVDMD. However, in this study proportion of leaf and leaf to stem ratio were negatively correlated with CP content and IVDMD. For instance, *Vicia narbonensis* has low number of stems, broad leaf and also thick and bold stem (erect growth habit) than the other species of vetch. The leaf proportion and leaf to stem ratio are higher in early maturing species (*V. narbonensis* and *V. sativa*) than intermediate to late maturing vetch species. Even though the leaf proportion and leaf to stem ratio are higher in early maturing species, lower CP content and IVDMD was obtained from this species. This could be attributed to high fiber and cell wall constituents in the stem parts due to erectness nature. The intermediate to late maturing species have large number of branches and narrow leaves that reduce the leaf proportion and leaf to stem ratio. Moreover, the stems are creeping growth habit due to low fiber and cell wall components so that the leaf and stem are highly palatable, because of higher CP content and digestibility.

Table 9: Correlation coefficients (r) between agro-morphological and nutritional traits of accessions of vetch species grown in the central highlands of Ethiopia

Traits	CP	CPY	NDF	ADF	IVDMD
Days to forage harvest	0.09	0.81***	-0.55**	0.16	0.17
Plant height at forage harvest	0.28	0.84***	-0.62**	0.17	0.35
Biomass production rate	-0.45*	-0.46*	0.44*	0.13	-0.37
Leaf fraction	-0.47*	-0.33	0.34	-0.20	-0.40
Stem fraction	0.31	0.30	-0.15	0.06	0.31
Leaf to stem ratio	-0.32	-0.80***	0.56**	-0.24	-0.41
Dry matter yield	0.19	0.83***	-0.53**	0.21	0.10
Grain filling period	0.10	0.41	-0.16	0.32	0.24
Seed yield	-0.30	-0.27	0.05	-0.17	-0.31

*P<0.05; **P<0.01; ***P<0.001; CP- Crude protein; CPY- Crude protein yield; NDF- Neutral detergent fiber; ADF-Acid detergent fiber; IVDMD- *In- vitro* dry matter digestibility.

Conclusions

Twenty accessions of different vetch species were evaluated for their nutritional differences at Holetta and Ginchi in the central highlands of Ethiopia. The forage nutritive values for vetch species and their accessions varied across testing sites at forage harvesting stage. Intermediate maturing and erect growth type vetch species had comparatively better ash, CP, CP yield and IVDMD contents, but lower fiber and cell wall constituents than early maturing and erect growth habit vetch species. Generally, *Vicia dasycarpa* had the highest ash content, CP content, CP yield, and IVDMD than the remaining vetch species at both testing sites. Among the nutritional parameters, CP was positively correlated with ash, CP yield and IVDMD, but negatively associated with NDF, ADF, cellulose and hemicelluloses contents. Forage DM yield was positively correlated with days to forage harvest, days to seed harvest, plant height at forage harvest, grain filling period number of pods per plant. On the other hand, it was negatively correlated with biomass production rate, leaf to stem ratio, grain sink filling rate, pod length, number of seeds per pod, thousand seed weight and seed yield. Similarly, seed yield was positively correlated with biomass production rate, leaf to stem ratio, grain sink filling rate, pod length, number of seeds per pod and thousand seed weight. However, it was negatively correlated with days to forage harvest, days to seed harvest, plant height at forage harvest, forage DM yield, grain filling period, and number of pods per plant. The correlation analysis between nutritive values indicated that IVDMD was positively correlated with ash, CP, CP yield, ADF and ADL contents. But it was negatively correlated with NDF, cellulose and hemicelluloses contents. Forage DM yield was positively correlated with CP, CP yield, ADF and IVDMD while inversely related with NDF content. Seed yield was positively correlated with NDF content whereas inversely related with CP, CP yield, ADF and IVDMD contents. Generally, vetch species and their accessions had different nutritional profiles and traits association in the central highlands of Ethiopia.

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Conflict of Interest

The author didn't declare any conflict of interest regarding to this article.

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