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CORRELATION AND CLUSTER ANALYSIS FOR QUANTITATIVE AND QUALITATIVE TRAITS OF ACCESSIONS OF VETCH SPECIES IN THE CENTRAL HIGHLANDS OF ETHIOPIA

Gezahagn Kebede
Ethiopian Institute of Agricultural Research, Holetta Research Center
P.O.Box, 31, Holetta,
Ethiopia
gezk2007@yahoo.co.uk

ABSTRACT

Twenty accessions of vetch species were evaluated for their characters association and cluster analysis at Holetta and Ginchi, in the central highlands of Ethiopia. The study was conducted in randomized complete block design with three replications. Data on agro-morphological traits and nutritive values were collected and the pearson correlation and cluster analysis procedure of SAS statistical package was applied for analysis of measured traits. The result showed that forage DM yield was positively correlated with days to forage and seed harvests, plant height at forage harvest, grain filling period and number of pods per plant. However, it was inversely related with biomass production rate, grain sink filling rate and seed yield. Among the nutritional parameters, the CP was positively correlated with ash, CP yield, ADL and IVDMD, but inversely related with NDF, ADF, cellulose and hemicellulose contents. The IVDMD was positively correlated with ash, CP, CP yield, ADF and ADL, but inversely related with NDF, cellulose and hemicellulose contents. The correlation analysis was also made between quantitative and qualitative traits and the result reveled that DM yield was positively correlated with CP, CP yield, and IVDMD, whereas inversely related with NDF content. The NDF was positively correlated with seed yield and biomass production rate. On the other hand, the CP content, CP yield and IVDMD were inversely related with seed yield and biomass production rate. The 20 accessions of vetch species were grouped into three clusters based on the mean values of measured traits. Based on measured traits, each clustering has its own characteristics and hence using their detailed data one can select a desired accession of vetch species for specific purpose of production. Therefore, the overall generated information on vetch species and their accessions in this study give a base for future vetch species breeding program to solve the feed problem in the central highlands of Ethiopia.

Key words: accessions, quantitative and qualitative traits, correlation, cluster analysis, vetch species

1. INTRODUCTION

Vicia is a genus of about 150 species commonly known as vetches, distributed all over the world (Hughes *et al*., 1962). Vetches are the most important and widely cultivated annual forage legumes 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. 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 for vetch species research will focus on improving the existing varieties and developing new ones to address the future demands. One of the main concerns in vetch species productions as well as in many agricultural crops production is to harvest increased yield and high 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.

Various statistical methods such as correlation (Berger *et al*., 2002; Iannucci *et al*., 2002) and cluster (Everrit, 1993) analysis could be used to determine the effect of yield components on yield. Correlation analysis provides the information on correlated response of important plant characters and therefore, leads to directional model for yield (Ali and Tahir, 1999). The correlation coefficient analysis generally measures the mutual relationship between various characters and determines the component traits on which selection can be relied upon to effect the improvement. 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). They also reported that this general relationships help to identify varieties that best fits to a specific purpose, with a reasonable forage yield, better quality and overall efficiency utilization. Cluster analysis is used to evaluate the characteristics of components and to categorize components into certain groups and subgroups in properties of similarity or dissimilarity (Eisen *et al*., 1998; Biljana and Onjia, 2007).

Yield in any crop depends on many component characters which influence the yield and quality either jointly or singly and either directly or indirectly through other related characters. Selection for yield and quality on the bases of *per se* performance alone may not be effective compared to selection based on the component character associated with it, which is biometrically determined by correlation coefficient. An understanding of the nature and extent of association of these components with yield and amongst themselves is an essential pre-requisite for formulating sound breeding program. The information on correlation is of great importance when simultaneous selection is to be carried out for more than one character to achieve the required improvement in yield and quality. Yield is the end product of interactions of many factors known as contributing components and hence it is a complex trait, selection directly based on this complex trait is usually not very useful, but the one based on its component traits could be more effective. To make effective selections for this complex trait, basic information on major contributing characters and their inter-relationships is essential to the plant breeder to ensure efficient selection evolving two or more characters. So correlation analysis helps the breeder to check out the selection strategy effectively for yield which is regulated and highly complex trait in which breeder is interested. Therefore, the objective for this study was to estimate correlation coefficients for important quantitative and qualitative traits and to cluster the accessions of vetch species based on measured traits.

2. MATERIALS AND METHODS

2.1 Descriptions of the study sites

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 (30 years) 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 thirty percent 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). The farming system of the study area is mixed crop livestock production where tef is the main staple crop complemented by other cereals such as barley and Wheat. In addition, faba bean, field pea and horticultural crops such as potato are the major crops growing in the area. The main feed resources in the area are natural pasture, crop residues and cultivated forage crops mainly oats/vetch mixture are grown by some farmers for their cross-bred dairy cows (HARC, 2009). 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 2200 m above sea level (masl) and characterized with the long term (30 years) 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). Tef is the main staple crop complemented by other cereals such as maize and sorghum. In addition, wheat, grass pea and chick pea are also some of the major crops growing in the area. The main feed resources are natural pasture and crop residues. Currently, farmers which have cross-bred dairy cows are willing to allocate their lands for cultivation of Oats, vetch and Napier grass to feed their animals (HARC, 2009).

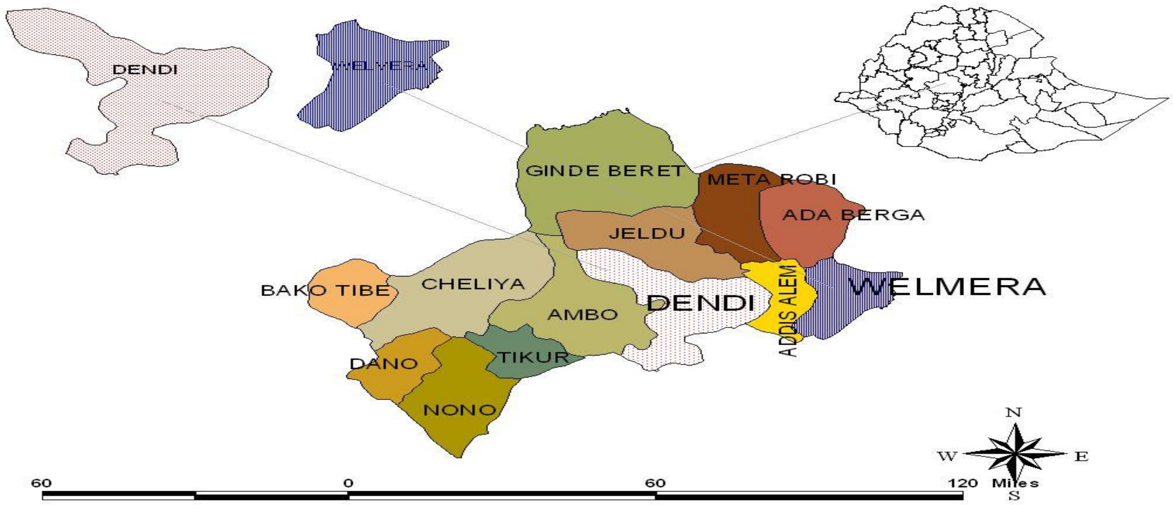

Fig 1: Map of the experimental sites, at Holetta (Welmera) and Ginchi (Dendi) in the central highlands of Ethiopia.

2.2 Experimental design and treatments

The study was executed using 20 accessions from five vetch species (Table1). All accessions of vetch species were selected on the basis of their adaptation to the central highlands of Ethiopia in the previous screening trials. The experimental fields were prepared following the recommended tillage practice (ploughing with a mould-board plough during the short rainy season in March followed by harrowing once using a disc harrow in early May and a slight hoeing to loosen the soil) 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 conditions. The experiment was conducted on a Randomized Complete Block Design (RCBD) replicated three times. 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. The two rows next to the destructive sampling rows were used to evaluate proportion of morphological fractions, forage yield and forage quality. The inner two rows were used for seed yield

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determination. A spacing of one meter was used between plots and between blocks. Based on experimental design, each treatment was assigned randomly to the experimental units within a block. The materials were sown according to their recommended seeding rates: 25 kg ha^{-1} for *Vicia villosa*, *Vicia dasycarpa* and *Vicia atropurpurea*; 30 kg ha^{-1} for *Vicia sativa* and 75 kg ha^{-1} for *Vicia narbonensis*. At sowing, 100 kg ha^{-1} diamonium phosphate (DAP) fertilizer was uniformly applied for all treatments at both locations. At Holetta, planting was done on 30th June 2009, while at Ginchi it was planted on the 3rd of July 2009. The first hand weeding was made thirty days after crop emergence (40 days after sowing/DAS) and the second weeding was done thirty days after the first weeding to minimize yield reduction due to competition for major growth resources such as nutrients, water and solar radiation. Generally, maximum cares were taken in the experimental plots to reduce the possible yield limiting factors which could affect the yield performance of vetch species and their accessions.

Table 1: Twenty accessions of five vetch species used as treatments for the experiment

SN	Species	Accessions	SN	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

2.3 Data collection and laboratory analysis

Days to forage and seed harvesting were counted from days to emergence to the date when 50 % of the plants gave flower and 75% of the plants produced matured seeds respectively. Plant height was measured from ground to the tip of the plant at the time of forage harvesting. For determination of biomass yield, accessions of vetch species were harvested at 50% flowering from two rows above the ground level. Weight of the total fresh biomass yield was recorded from each plot in the field and the estimated 500 g sample taken from each plot and weighed to know the total sample fresh weight using sensitive table balance and then manually fractionated in to leaf, stem and green pod and flower. The morphological parts were separately weighed to know their sample fresh weight, oven dried for 72 hours at a temperature of 65 ^{o}c and separately weighed to estimate the proportions of these morphological parts. The leaf to stem ratio then computed in dry matter basis of each component. Biomass production rate also computed by dividing the above ground biomass yield to number of days to 50% flowering and expressed as kg ha^{-1} day^{-1}. Six plants were randomly taken and uprooted at seed setting stage from two destructive sampling rows of each plot for determination of number of pods per plant. Six pods were then randomly taken to measure pod length and the number of seeds per pod was counted. The inner most two rows of each plot was maintained for seed yield determination. The plants were harvested at ground level at the optimum seed harvesting time (visual observation due to indeterminate growth) and total seed yield was determined from two rows after threshing and winnowing. Seed samples were taken and oven dried at 100°c for 48 hours to adjust moisture content of 10%, a recommended percentage level for legumes (Biru, 1979). Seed yield (t ha^{-1}) and thousand seed weight (g) were then calculated at 10% moisture content. Grain filling period (GFP) and grain sink filling rate (GSFR) were also used to determine seed yield related performance. Number of days between days for flower initiation and days to seed maturity is known as GFP, while GSFR is calculated as the ratio of grain yield to number of days from flower initiation to seed maturity and expressed as kg ha^{-1} day^{-1}.

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The other estimated 500 g sample taken from each plot was oven dried for 72 hours at a temperature of 65 ^{o}c. The oven dried samples were used for laboratory analysis to determine chemical composition and *in-vitro* dry matter digestibility of the materials. 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 ^{o}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 (Givens *et al*., 1997; Herrero *et al*., 1997; Adesogan *et al*., 1998; Park *et al*., 1998). Hemi-cellulose and cellulose contents were estimated from subtracting ADF from NDF and ADL from ADF respectively. The CP yield in t ha^{-1} was calculated by multiplying CP with total dry biomass yield and then divided by 100.

2.4. Statistical analysis

The Pearson correlation analysis procedure of the SAS statistical package was applied to measure the strength of linear dependence between two measured variables (SAS, 2002). The analysis was made between the major quantitative traits, qualitative traits and between quantitative and qualitative traits. The cluster analysis procedure was used to group the accessions of vetch species into different clusters based on observed traits using SAS statistical package (SAS, 2002). The accessions within a cluster were relatively similar or homogeneous to one another and different from the other clusters for measured traits.

3. RESULTS AND DISCUSSION

3.1. Correlations between agro-morphological traits

The linear correlation coefficients between observed agro-morphological traits are shown in Table 2. 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 (Tewari and Gautam, 1989; Oseni *et al*., 1992). Generally, 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. Generally, 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.

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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. Generally, 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.

Table 2: Correlation coefficients (r) between agro-morphological traits of accessions of vetch species grown in the central highlands of Ethiopia

Traits	DFH	DSH	PHFH	BPR	LSR	FDMY	GFP	GSFR	NPP	PL	NSP	TSW
DSH	0.95***											
PHFH	0.94***	0.92***										
BPR	-0.39	-0.18	-0.40									
LSR	-0.80***	-0.91***	-0.95***	0.32								
FDMY	0.85***	0.83***	0.86***	-0.14	-0.80***							
GFP	0.56**	0.79***	0.57**	-0.17	-0.63**	0.47*						
GSFR	-0.49*	-0.42	-0.49*	0.39	0.35	-0.40	-0.22					
NPP	0.89***	0.91***	0.94***	-0.39	-0.94***	0.70**	0.68**	-0.49*				
PL	-0.87***	-0.87***	-0.88***	0.47*	0.86***	-0.60**	-0.68**	0.57**	-0.96***			
NSP	-0.39	-0.49*	-0.46*	0.24	0.52*	-0.02	-0.61**	0.31	-0.66**	0.74**		
TSW	-0.82***	-0.76**	-0.79***	0.25	0.69**	-0.91***	-0.39	0.43	-0.66**	0.58**	-0.08	
SY	-0.26	-0.16	-0.26	0.40	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

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). Generally, 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

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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 (Anlarsal *et al*., 1999). 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 (Sindhu *et al*., 1985; Nigem *et al*., 1990); number of pods per plant and number of seeds per pod in common vetch (Anlarsal *et al*., 1999); and number of pods per plant in mung bean (Kumar *et al*., 2002).

3.2. Correlations between nutritional traits

The linear correlation coefficients between nutritional traits are shown in Table 3. 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 hemicellulose content (r= 0.09). According to Diriba (2003), ash was positively correlated with CP, NDF and ADF, but poorly and negatively associated with lignin, cellulose and hemicellulose 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 hemicellulose 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 high positive correlations with IVDMD, whereas NDF, ADF, ADL and cellulose showed negative correlations with IVDMD in Napier grass harvested at different heights.

Table 3: 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	
Hemi-cellulose	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.

The NDF content was significantly (P<0.001) and positively correlated with hemicellulose (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 hemicellulose 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 hemicellulose. Both cellulose and hemicellulose 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 hemicellulose content (r= -0.43). Fekede (2004) also reported that Oats varieties had negative but non-significant correlation between cellulose and hemicellulose content.

3.3. Correlations between agro-morphological and nutritional traits

The linear correlation coefficients between agro-morphological and nutritional traits are shown in Table 4. 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. Generally, 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). Generally, 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). Generally, 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). Generally, 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). Generally, early maturing accessions had higher biomass production rate, leaf proportion, leaf to stem ratio, and seed yield, but had lower IVDMD than intermediate to late maturing ones. This could be due to higher CP and lower fiber in the latter than the former.

Generally, 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.

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Table 4: Correlation coefficients (r) between agro-morphological and nutritional traits of accessions of vetch species grown in the central highlands of Ethiopia

Agro-morphological traits	Nutritional 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.

3.4. Performances of accessions in different clusters for major observed traits

The tested accessions of vetch species were clustered based on the measured traits as indicated in Tables 5 and 6 and in Figure 2. Even though the accessions of vetch clustered within the species, they showed some similarities and differences for major measured traits. Some of the accessions from the different vetch species grouped in one cluster. This could be due to the presence of wide similarities among the species as well as accessions within the species for observed traits. Therefore, using this cluster and their detailed data, one can select a group of desired accessions of vetch with similar characteristics from each cluster for a specific target of production. Getnet *et al*., (2003) in the study of oats characterization reported that clustering with the supplementary detailed data would assist users to select a variety appropriate for a particular target of production and utilization so that it best fits to the farming system, feed conservation practice, feeding system and other complementary advantages. The 20 accessions of vetch species were grouped into three clusters based on the mean values of the measured production traits. Total number of accessions and their lists under the three clusters are shown in Table 5. Cluster 1 consisted of 9 accessions of vetch. From the 9 accessions, 6 of them were originated from *Vicia villosa* accessions while the remaining 3 accessions contributed from *Vicia dasycarpa* (Namoi and Lana) and *Vicia atropurpurea* (Atropurpurea). On the other hand, cluster 2, and 3 each had 6, and 5 accessions respectively. Cluster 2 had all *Vicia sativa* accessions, whereas cluster 3 consisted of all *Vicia narbonensis* accessions.

Table 5: Total number of accessions of vetch species and their list under three clusters

Cluster number	**Number of accessions**	**List of accessions**
1	9	5, 2450, 2424, 2438, 2434, 2446, Namoi, Lana & Atropurpurea
2	6	66, 61904, 61744, 61509, 61039, 61212
3	5	4, 2387, 2380, 2392 & 2376

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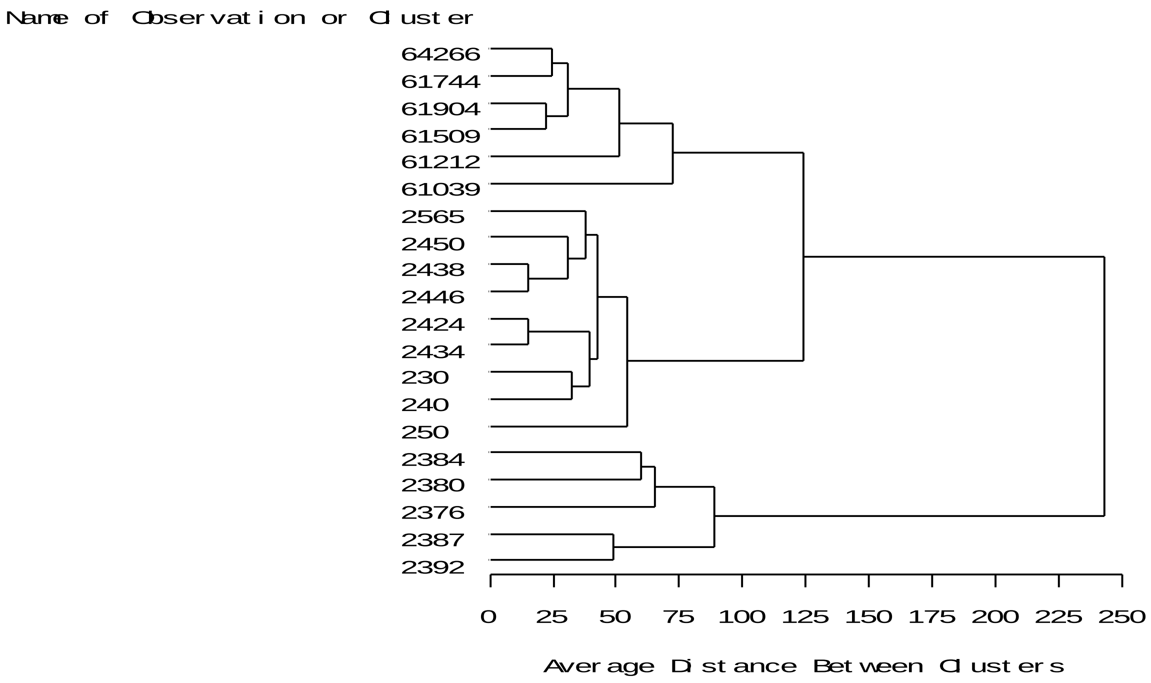
Table 6: Cluster mean values for major measured traits of different accessions of vetch species grown in the central highlands of Ethiopia

Traits	Cluster		
	1	**2**	**3**
Days to forage harvest	113.7[a]	102.0	90.1[b]
Plant height at forage harvest (cm)	151.15[a]	94.8	50.4[b]
Days to seed harvest	150.8[a]	135.5	124.1[b]
Biomass production rate (kg ha^{-1} day^{-1})	43.0[b]	55.2	57.1[a]
Leaf to stem ratio	0.4[b]	0.6	0.7[a]
Dry matter yield (t ha^{-1})	6.5[a]	5.9	1.8[b]
Grain filling period (days)	71.9[a]	63.3[b]	63.5
Grain sink filling rate (kg ha^{-1} day^{-1})	93.8[b]	120.9	124.7[a]
Seed yield (t ha^{-1})	1.5[b]	1.7	1.8[a]
Thousand seed weight (g)	44.5[b]	52.0	232.6[a]
Crude protein content (% DM)	22.7[a]	18.9[b]	22.4
Crude protein yield (t ha^{-1})	1.3[a]	1.1	0.7[b]
Neutral detergent fiber (%DM)	45.6[b]	47.3	54.6[a]
In-vitro dry matter digestibility (%DM)	67.8[a]	60.4[b]	66.5

[a]= highest value; [b]= lowest value



Where, Namoi, Lana and Atropurpurea represented as 230, 240 and 250 respectively

Fig 2: Dendnogram showing the groupings of vetch accessions based on the major traits on the average alogarithm using standard values.

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Table 6 shows the cluster mean values for major observed traits of different accessions of vetch species grown at Holetta and Ginchi. The mean values for different observed traits within each cluster were compared with the other clusters, and hence cluster 1 was characterized by late maturity, tall plant height, long grain filling period; high forage DM yield, CP content, CP yield, IVDMD; and low biomass production rate, leaf to stem ratio, grain sink filling rate, thousand seed weight and NDF content. The main characteristics of cluster 2 were low grain filling period, CP content, and IVDMD. The higher biomass production rate, leaf to stem ratio, grain sink filling rate, seed yield, thousand seed weight and NDF content; whereas late maturity, short plant height, low DM and CP yields were observed to be the main characteristics of cluster 3. Figure 2 shows the clustering of the accessions of vetch species according to the major production traits. Hence, accessions in each cluster had more or less similar days to forage harvest, plant height at forage harvest, days to seed harvest, biomass production rate, leaf to stem ratio, forage DM yield, grain filling period, grain sink filling rate, seed yield, thousand seed weight, CP and NDF contents, CP yield and IVDMD. Based on the overall measured traits, the accessions were clustered to groups and hence, one can select a variety or accession from each group for desired purpose of production.

4. CONCLUSION

Twenty accessions of vetch species were evaluated for their characters association and cluster analysis at Holetta and Ginchi, in the central highlands of Ethiopia. The result showed that 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 hemicellulose 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. The cluster analysis indicated that 20 accessions of vetch species were grouped into three clusters based on the mean values of the measured production traits.

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