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Full-Length Research Article

Strategies to Improve the Quality of Fibrous Feeds: Evaluating the Potential of Cow Pea (*Vigna unguiculata*) Accessions Grown under Sub-Humidid Climate Conditions in Western Ethiopia

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ABSTRACT

Five selected cowpea accessions (ILRI 9325, ILRI 11976, ILRI 6782, ILRI 6783, and WWT) were evaluated for herbage dry matter (DMY) and crude protein (CPY) yields and nutritive value. Among the tested accessions, ILRI 9325, ILRI 6782, ILRI 6783, and WWT gave higher and comparable yields ($P<0.01$ for DMY; $P = 0.05$ for CPY), with ILRI 9325 giving superior yields. The overall CP content was 17%, with a range of 16% for WWT to 18% for ILRI 9325. The overall mean for neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin were 43%, 34%, and 6%, respectively. The *in vitro* organic digestibility (IVOMD) ranged from 64% (ILRI 6783) to 69% (WWT). The relative feed value (RFV) index averaged 135 (range = 128–142). The mean metabolizable energy (ME) content was 10 MJ/kg DM, with a range of 9.5 to 10.4. Three accessions that combined high biomass DM and crude protein yields and herbage quality were: ILRI 9325, ILRI 11976, and WWT. The two former accessions can thus be promoted to the next variety verification stage alongside WWT as a check to identify one or two alternative cowpea varieties for official release.

Key words: *Vigna unguiculata*, Herbage DM yield, Crude protein yield, Chemical composition, Relative Feed Value, Metabolizable energy.

Abbreviations: DM, dry matter; DMY, dry matter yield; CPY, crude protein (CP) yield; NDF, neutral detergent fibre; ADF, acid detergent fiber; ADL, acid detergent lignin; RFV, relative feed value; ME, metabolizable energy.

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1. INTRODUCTION

Population growth and expanding demand for agricultural products are constantly increasing the pressure on native grazing lands that have traditionally been used as a major source of livestock feed in Ethiopia. This scenario is resulting in an increasing contribution of crop residues as livestock feed (Melaku *et al*., 2005). But crop residues are characterized by low crude protein and energy contents and high levels of cell wall fractions (Fekadu *et al*., 2010; Tolera and Sundstol, 2000). As a result, their intake level is limited, and they hardly fulfill even the maintenance requirements of animals (Melaku, 2004). Presently, a larger proportion of animal products are produced by smallholder crop-livestock mixed farmers in such poor livestock feed resource situations. As much of the arable land is already under cultivation, increased livestock output will thus have to come from improving livestock productivity. This could be achieved through the introduction of low-cost feeding technologies that are easy and convenient to use, consistently reproducible, and within the limits of the resources of poor crop-livestock mixed farmers. This suggests the need to search for alternative feeding strategies that would help enhance the quality of these low-quality feeds. Integration of appropriate leguminous forage species into the existing feeding systems has continually been advocated as one of the options that have to be exploited.

With this background, forage legume selection activities are in progress under different agro-ecologies in the country, with a number of candidate genotypes at advanced stages of varietal selection. One of the potential forage legume species currently being evaluated is the cowpea (*Vigna unguiculata* L. Walp). Cowpea has the potential to serve as a key legume species for intensifying the crop and livestock production systems by supplying protein in human diets and fodder for livestock, as well as bringing nitrogen into the farming system through biological fixation (Etana *et al*., 2013; Agza *et al*., 2012; FAO, 2009). However, in the current selection programs, more attention has mainly been given to the evaluation of the environmental adaptation and seed and herbage production potential of a limited number of candidate accessions (see, for example, Etana *et al*., 2013; Agza *et al*., 2012), and as a result, information on their nutritive value is generally scarce. This implies the need for research focusing on the characterization of the nutritional quality of elite cowpea accessions grown under varying production systems and agro-ecological conditions if their potential in livestock feeding is to be effectively exploited. Also, following the national forage variety testing and release system recently adopted in Ethiopia, availing information on quality constituents of elite forage accessions at advanced stages of varietal development has become compulsory before the candidate materials are officially released for wider use. Establishing genotypic differences in forage quality also offers opportunities for selecting appropriate cowpea varieties for diverse production systems (Anele *et al*., 2011). The objective of the present study, therefore, was to assess the herbage dry matter (DMY) and crude protein (CPY) yields and chemical composition, *in vitro* organic matter digestibility (IVOMD), and metabolizable energy (ME) contents of elite accessions of cowpea grown under subhumid and medium-altitude climatic conditions in western Ethiopia.

2. MATERIALS AND METHODS

2.1 Location

The experiment was conducted at the Bako Agricultural Research Centre (BARC), located in subhumid areas of western Oromia, Ethiopia, during the main rainy seasons of 2012 (Year 1) and 2013 (Year 2). The area receives a mean annual rainfall of 1200mm, 90% of which falls between June and September. The temperature averages 27 oC with a range of 22 to 31 oC (BARC meteorological station). Dominant soil types are Nitosols with fertile alluvial soils in valley bottoms. Maize, teff (*Eragrostis tef*), noug (*Guizotia abyssinica*), sorghum, and finger millet are the main crops grown in the area (BARC, 2003).

2.2 Treatment description

Five elite accessions of cowpea, four of them selected from prior advanced forage variety trials, were evaluated together with an already registered cultivar, *V. unguiculata* WWT (to be referred to hereafter as WWT), that was used as a standard check. Seeds of the four accessions (ILRI 9325, ILRI 11976, ILRI 6782, and ILRI 6783) were obtained from the forage diversity gene bank of the International Livestock Research Institute (ILRI) in Addis Ababa, and those of WWT were obtained from the Animal Feeds and Nutrition Research Division at BARC.

2.3. Experimental design

The seeds of the experimental accessions were planted on 6 m2 plots (2 m long and 3 m wide) with six rows arranged length-wise in an east-west direction, with intra-row spacing of 50 cm, and replicated two times in a completely randomized block design. Within rows, the seeds were placed at a 10cm distance from each other, with each row containing 20 plants. Crop management practices (hoeing, weeding, etc.) were practiced as required, and no chemical fertilizer was applied during both seasons. At the pod initiation stage, two randomly selected middle rows with a net area of 2 m2 were harvested, and the fresh biomass weight was taken using field balance. The harvested herbage mass was manually chopped into small pieces using a sickle, and a subsample of 200 grams was taken and dried in an air-draft oven at 65 oC for 72 hours to determine herbage DM yield. Crude protein yield (CPY) was estimated as the product of CP content and herbage DM yield (Starks *et al*., 2006).

2.3 Chemical analysis

For forage quality analysis, chopped herbage from the two replications was pooled and properly mixed, and one representative subsample was taken for each accession and dried as previously indicated. The DM and ash contents were determined by oven drying at 105°C overnight and by igniting in a muffle furnace at 600°C for 6 hours, respectively. Nitrogen (N) content was determined by the Kjeldahl method, and CP was calculated as Nx6.25 (AOAC, 1995). The neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) contents were analyzed according to the methods of Van Soest ***et al***. (1991). The modified Tilley and Terry ***in vitro*** method was used to determine the IVOMD (Van Soest and Robertson, 1985), and metabolizable energy (ME) content was estimated from the IVOMD using the equation ME (MJ/kg DM) = 0.15*IVOMD (Beever and Mould, 2000).

2.4. Relative feed value (RFV)

The RFV is an index used to rank feeds relative to the typical nutritive value of full-bloom alfalfa hay, containing 41% ADF and 53% NDF on a DM basis and having an RFV of 100, which is considered to be a standard score. The index has no units but is now widely used to compare the potential of two or more forages on the basis of energy intake. Forages with RFV greater than 100 are considered to have higher quality than full-bloom alfalfa hay, and those with a value lower than 100 are of lower value than the same. Such a single parameter was suggested to be very useful for

practical forage pricing and marketing (Schroeder, 2013; Uttam ***et al***., 2010) and was calculated as :$RFV = DDM\ (\%DM)\text{x}\frac{DMI(\%BW)}{1.29}$
$(Uttam\ et\ al., 2010)$;

Where, DDM (digestible dry matter) and DMI (dry matter intake potential as % of body weight) were calculated from ADF and NDF, respectively as:

$DDM\ (\%\ DM) =\ 88.9 - 0.78\ \text{x}ADF\ (\%\ DM)$ and $DMI\ (\%BW) = \frac{120}{NDF}(\%\ DM)$

x: Is it the multiplication sign of the letter "X"

2.5 Data analysis

The herbage DM and CP yield data were subjected to analysis of variance using the Generalized Linear Model (GLM) procedure of SAS (SAS, 2002). Year, accession, and the interaction between year and accession were considered as class variables in the model, as shown below:

$$Xij = \mu + Yi + Vi + (Yi * Vi) + eij;$$

where *Xij* is herbage DM yield, μ is the overall mean; *Yi* is the effect of year; *Vi* is the effect of accession; and, *Yi*Vi* is the interaction between year and accession, and *eij* is the random error.

For herbage quality traits, year was considered as replicate and hence the data was fitted to the following model.

$$Xij = \mu + Yi + eij;$$

where *Xij* is standing for the quality traits determined; μ for the overall mean; *Yi* for the effect of year (replicate), and *eij* for the random error. The GLM procedure of SAS was used for analyzing the data (SAS, 2002) and significant mean differences were declared at P ≤ 0.05 using Least Significant Difference (LSD) test (Snedecor and Cochran, 1980).

3. RESULTS

3.1 Herbage dry matter (DMY) and crude protein (CPY) yields

Table 1 show the mean herbage DM and CP yields for cowpea accessions as affected by year and accessions. Results from the analysis of variance for herbage DMY revealed no significant effect of year (P > 0.05) but that of accessions and the interaction between year and accessions to be significant (P< 0.01). A slightly higher mean DMY average over the five accessions was recorded during Year 1 (12.54 t/ha) than Year 2 (10.74 t/ha). Significantly (P<0.01) higher and comparable herbage DMY was recorded for ILRI 9325, WWT, ILRI 6782, and ILRI 6783. On the contrary, ILRI 11976 gave significantly lower (P<0.01) herbage DMY (7.96 t/ha). The CPY also followed a pattern similar to that of the herbage DMY. Accordingly, a significantly higher CPY was recorded for the first year (P = 0.01) compared to the second year. Four of the five accessions (ILRI 9325, WWT, ILRI 6782, and ILRI 6783) had significantly higher (P = 0.05) and comparable CPY, with values for ILRI 9325 being the highest (254.97 t/ha), whereas significantly lower CPY (P = 0.05) was recorded for ILRI 11976.

Table 1. Herbage DM (DMY) and CP (CPY) yields (t/ha) of *Vigna unguiculata* as influenced by year and accession

Factors	**Description of the factors**	**DMY**	**CPY**
Year	Year 1	12.54±0.62	243.26±15.15a
	Year 2	10.74±0.62	170.67±15.15b
Accession	WWT	13.68a±0.98a	225.29±23.95a
	ILRI 9325	13.95a±0.98a	254.97±23.95a
	ILRI 11976	7.96b±0.98b	141.03±23.95b
	ILRI 6782	11.41±0.98a	191.03±23.95ab
	ILRI 6783	11.21±0.98a	200.01±23.95ab

Note: Year and accession means with no superscript letter in common are significantly different

3.2 Herbage Nutritive Value

Table 2 presents the mean values for herbage quality traits for the five cowpea accessions. Except for DM content (P<0.01), no significant variation between accessions was detected in forage quality traits (P>0.05). The mean ash content was 9%, and that of CP was 17%, with values for the latter ranging from 16% for WWT to 18% for ILRI 9325. The overall mean NDF, ADF, and ADL contents were 43%, 34%, and 6%, respectively. The IVOMD values ranged from 64% for ILRI 6783 to 69% for WWT, with an overall mean of 67%. Similarly, the RFV index averaged 135, with a value of 128 for ILRI 6782 and 142 for WWT. The overall ME (MJ/kg DM) content was around 10, ranging from 9.5 for ILRI 6783 to 10.4 for WWT.

Table 2. Nutritive value of different accessions of *Vigna unguiculata* (n = 2)

Accessions	**DM %**	**Ash**	**CP**	**NDF**	**ADF**	**ADL**	**IVOMD**	**RFV#**	ME
		% DM							MJ/kg DM
WWT	91.65ab	9.05	16.37	42.68	31.07	5.62	69.43	142.16	10.42
ILRI 9325	90.93c	9.30	18.18	42.92	34.12	6.73	68.65	135.85	10.30
ILRI 11976	90.99c	9.25	17.96	43.44	31.65	5.27	68.35	139.09	10.26
ILRI 6782	91.87a	9.05	16.46	43.70	37.83	6.26	65.61	127.89	9.84
ILRI 6783	91.51b	9.25	17.84	43.78	36.53	6.36	63.56	128.63	9.54
Overall	91.39	9.18	17.36	43.30	34.24	6.05	67.12	134.72	10.07
SE	0.08	0.6	1.14	3.69	2.47	0.54	2.19	15.30	0.33
P level	***	NS	NS	NS	NS	NS	NS	NS	NS

Note: DM, dry matter; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin; IVOMD, *in vitro* organic matter digestibility; RFV, relative feed value; ME, metabolizable energy; ***, significant at P<0.001; NS, non-significant; SE, standard error for accession mean; #relative feed value index has no unit; SE, standard error for accession means.

4. DISCUSSION

4.1 Herbage DMY

The herbage DMY observed in the first year was slightly higher than that of the second year (by around 8%), with the two values being statistically the same. The similarity in mean herbage DMY between the two seasons might be linked to similarity in environmental variables like amount and distribution of rainfall and temperature during the two cropping seasons. The significant difference between accessions in herbage DMY observed in this study is in agreement with other reports (Anele *et al*., 2011a; Singh *et al*., 2003), in which improved and local varieties were compared and higher herbage DM yield values were recorded for improved varieties compared to the local ones (Singh *et al*., 2003). Anele *et al*. (2011a) also reported significant (P<0.05) differences in herbage DM yield between commercial and improved cowpea varietal groups. The mean values for herbage DMY recorded in four of the accessions (WWT, ILRI 9325, ILRI 6782 and ILRI 6783) are higher than values reported for three commercial (6.46 t/ha) and three improved (8.76 t/ha) groups of cowpea elsewhere (Anele *et al*., 2011b). On the other hand, the herbage DMY for ILRI 11976 (7.96 t/ha) is comparable with a reported mean value of 8.76 t/ha reported for three improved cowpea cultivars grown in Southwest Nigeria (Anele *et al*., 2011b).

4.2 Nutritive value

The overall mean for CP observed in the present study (17%) is comparable to a mean of 18% (n = 3) reported elsewhere (Anele *et al*., 2011b) but relatively lower than 23% (n = 4) reported by Ravhuhali *et al*. (2010). A wide range of CP values has been reported in the literature and this might be linked to differences in crop management (Sing *et al*., 2010), variety (Anele *et al*., 2011a; Ravhuhali *et al*., 2010), plant part (Savodogo *et al*., 2000; Rivas-Vega *et al*., 2006) or season of the year (Anele *et al*., 2011a; Anele *et al*, 2011b). For instance, Singh *et al*. (2010) reported a mean CP value of 13% for cowpea samples taken from a field to which farm yard manure was applied and a value of 14% for those grown on land to which chemical fertilizers (urea, DAP and muriate of potash) were applied. Similarly, Ravhuhali *et al*. (2010) reported significant varietal differences with CP values ranging from around 20% to 26% in a study where four cowpea varieties were evaluated. Crude protein contents of about 8% and 15% were also reported for the stem and leaf fractions, respectively (Savodogo *et al*., 2000). A significant seasonal variation (P<0.001) on CP content of two groups of cowpea varieties (with each group consisting of three cultivars) was also reported with a respective mean values of 16% and 21% for herbage samples collected during wet and dry seasons (Anele *et al*., 2011a). Generally, the overall mean value for CP content of the accessions tested (17%) was higher than 15%, a threshold value usually required to support lactation and growth in dairy cattle (Nsahlai *et al*., 1996), indicating the adequacy of fodder from the accessions tested to be used as a supplement to animals depending on roughage diets of poor quality. When the accessions are specifically ranked based on CP content *per se*, ILRI 9325 was observed to contain comparatively higher CP levels.

The mean NDF content (n = 5) observed for cowpea accessions in the present study (43.3%) is comparable to the 45% reported for four cowpea cultivars (Ravhuhali *et al*., 2010). Mean NDF values of around 54% (Dahmardeh *et al*., 2010), 56% (Singh *et al*., 2010), and 61% (Anele *et al*., 2011a), which are apparently higher than those observed in the present work, were also reported. The mean ADF content of 34% found in this study is comparable to that reported for a variety named ‘Agripes’ (33%) but higher than that of ‘Blackeye’ (24%) reported elsewhere (Ravhuhali *et al*., 2010). Dahmardeh *et al*. (2010) reported a mean ADL content of 16% and 18% for forage samples of pure stand cowpea grown during two successive seasons. Similarly, Anele *et al*. (2011b) reported a respective ADL content of around 21% and 16% for commercial and improved cowpea varieties (with three varieties in each group). Hence, the mean ADL content of 6% in the present study is much lower than the aforementioned literature values, but Singh *et al*. (2010) reported an ADL content of 9%, which is relatively closer to that observed in the study now being discussed. According to Kazemi *et al*. (2012), forage legumes with respective NDF and ADF values falling within a range of 40%–46% and 31%–40% are rated as having a first-grade quality standard. The NDF and ADF contents of the accessions evaluated in this work fall within these ranges, indicating their potential to be used as a source of supplement for improving the feeding value of poor-quality roughages.

The mean IVOMD for the five accessions (67%) is higher than the threshold value of 50% required for feeds to be considered to have acceptable digestibility (Owen and Jayasuriya, 1989) and is also superior to those reported earlier for other herbaceous (65%) and browses (55%) legume species (Bediye *et al*., 1996). The mean RFV index of around 135 observed for the five cowpea accessions in the present study falls within the range of 125–151 required for legume hays to be considered as having a quality status of first grade (Kazemi *et al*., 2012). Moreover, the observed mean RFV index exceeds a standard value of 100 for full-bloom alfalfa, implying the higher nutritive value of the accessions evaluated. The mean ME of 10 MJ/kg DM observed in this work is quite similar to that reported earlier for other protein supplements (Bediye *et al*., 1999) (10 MJ), both of which are greater than the critical threshold of 7.5 MJ/kg DM (Owen and Jayasuriya, 1989).

In general, taking into consideration the herbage DM and CP yields and the observed herbage quality attributes, three of the top-ranking accessions combining high biomass production and superior quality attributes were: ILRI 9325, ILRI 11976, and WWT. Indeed, WWT is a registered cultivar that was included as a standard check in this experiment. The other two accessions can thus be promoted to the next stage of varietal evaluation alongside WWT as a standard check to identify one or two alternative varieties for official release for wider production.

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