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Herbage Yield and Quality of Selected Accessions of Centrosema Species Grown under Subhumid Climatic Conditions of Western Oromia, Ethiopia

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Abstract: The study was conducted at Bako Agricultural Research Center during main rainy seasons of 2012 and 2013 to identify superior accessions of Centrosema species based on their herbage DM (DMY) and crude protein (CPY) yields and forage quality attributes. Five elite accessions (*C. pubescens* ILRI 233, *C. pubescens* ILRI 243, *C. pubescens* ILRI 12297, *C. plumieri* ILRI 191 and *C. virginianum* ILRI 14541) were evaluated in a randomized complete block design with two replications. The DMY and CPY values were significantly affected by year ($P<0.001$) and accession ($P = 0.05$ for DMY; $P<0.05$ for CPY). Significantly higher DMY values were recorded for *C. pubescens* ILRI 243 (7.35 t ha^{-1}), *C. plumieri* ILRI 191 (7.35 t ha^{-1}) and *C. virginianum* ILRI 14541 (7.10 t ha^{-1}). The crude protein (CP) content ranged from 18.86% (*C. pubescens* ILRI 243) to 22.37% (*C. virginianum* ILRI 14541), with overall mean of 21.02%. The overall mean neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) values were 49.98%, 35.71% and 9.42%, respectively. The *in vitro* organic matter digestibility (IVOMD) ranged from 38.62% (*C. pubescens* ILRI 233) to 50.69% (*C. plumieri* ILRI 191). The relative feed value (RFV) varied from 106 (*C. pubescens* ILRI 243) to 126 (*C. plumieri* ILRI 191). The overall metabolizable energy (ME) content was 6.58 MJ/kg DM, ranging from 5.79 (*C. pubescens* ILRI 233) to 7.61 (*C. plumieri* ILRI 191). It was concluded that *C. plumieri* ILRI 191, *C. pubescens* ILRI 12297 and *C. Virginianum* ILRI 14541 top performing accessions and can thus be promoted to the next variety verification stages.

Key words: *Centrosema pubescens* · Crude Protein Yield · Digestibility · Relative Feed Value

INTRODUCTION

The livestock subsector is a vital constituent of Ethiopian agriculture and plays a considerable role as a strategic subsector to offset the widespread social and economic consequences of poverty [1]. The productivity of the sector, however, is hindered by a number of technical and non-technical constraints, among which feed scarcity in both quality and quantity is the principal one. Though indigenous pastures traditionally contributed much to livestock feed supply, current trends indicate that they are gravely overstocked and existing grazing areas are gradually shrinking due to encroachment of crop production which is induced by the need to feed the increasing human population specially in developing country [2- 4].

Crop residues are used as livestock feed in Ethiopia mainly under crop-livestock mixed production systems. But crop residues are characterized by their low crude protein and energy levels and high concentration of cell wall fractions [5, 6]. As a result, their intake level is limited and they barely fulfill even the maintenance requirements of animals for essential nutrients [2, 7]. Though crop residues can significantly contribute to livestock

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productivity improvement, current residue based feeding practices are without appreciation of production responses that could be achieved with supplementation and treatment. As a result, under scenarios of intensifying crop-livestock production systems, current and future strategy in livestock feeding need to be on maximizing the use of these feeds by using, among others, various leguminous forages as supplements. The scientific basis of feeding forage legume supplements to ruminant livestock subsisting on poor quality forages has been discussed in a number of works [8, 9] and the efficient use of such feeds need to be a focus of attention for ensuring sustainable availability of animal source proteins for human consumption in Ethiopia as well.

With this background, forage legume germplasm selection activities are in progress under different agro-ecologies of the country with a number of candidate genotypes at advanced level of varietal selection stages at present. Centrosema species are one of the potential forage legumes being considered mainly for sub-humid medium altitude zones in western Ethiopia. In these selection programs more attention has traditionally been given to assessment of their environmental adaptation and herbage production potential, but information on their nutritional quality database is generally scarce, suggesting the need for research focusing on determination of nutritional attributes for candidate forage species grown under varying production systems and agro-ecological conditions. Furthermore, following the national forage variety testing and release policy recently adopted, making feed quality data available for elite forage species being evaluated at advanced varietal selection stages has become essential for the promising accessions to be officially released and registered. Furthermore, establishing information on attributes of nutritional value besides that of herbage biomass and nutrient yields as influenced by genotype offers opportunities for selecting appropriate varieties for a given production system. The present study, therefore, was undertaken to assess differences in herbage DM and CP yields and CP, NDF, ADF, ADL, IVOMD and RFV of five elite accessions of Centrosema (*C. pubescens* ILRI 233, *C. pubescens* ILRI 243, *C. pubescens* 12297, *C. plumieri* ILRI 191 and *C. virginianum* ILRI 14541) belonging to three species (*C. pubescens, C. plumieri and C. virginianum*) under Bako condition, a site representing subhumid medium altitude agro-ecologies of western Oromia, Ethiopia. This was carried out to identify superior accessions for final verification at the final stage of evaluation and then release best performing ones as variety.

MATERIALS AND METHODS

Location: The experiment was conducted at Bako Agricultural Research Centre located in western Oromia, Ethiopia during the rainy seasons of 2012 (Year 1) and 2013 (Year 2). The site receives an annual rainfall of 1200 mm, 90% of which falls between June and September. Temperature averages 27°C with a range of 22°C to 31°C (Bako Research Center, Meteorological station). Dominant soil types are Nitosols with fertile alluvial soils in valley bottoms. Maize, teff (*Eragrostis tef*), noug (*Guizotia abyssinica*), pepper, sorghum and finger millet are the main crops of the area [10].

Treatment Description: Five elite accessions of Centrosema belonging to three Centrosema species and adapted to the sub-humid medium altitude climatic conditions of western Ethiopia were evaluated (Table 1).

Experimental Layout for Herbage DM Yield Determination: Five gram of seed of each accession was uniformly drilled in double-rows of 2m long with a spacing of 50cm between rows in $2m^2$ (1m*2m) plot area. The two rows in each plot were drawn lengthwise in east-west direction at 25cm distance away from right and left margins and replicated two times, the distance between the plots within replication being 1m and that between the two replications being 1.5m. The experimental plots were laid out in randomized complete block design.

Table 1: Description of the species and accessions of Centrosema evaluated in the study

Species	ILRI accession number	Collector(s) name	Country of collection	1000 seed weight (g)
C. pubescens	233	Neal R.	Belize	31.82
C. pubescens	243	Fernandez R., Stassen C.	Belize	19.96
C. pubescens	12297	Grof P.	Colombia	19.80
C. plumieri	191	Neal R., Stassen C., R. Fernandez	Belize	108.06
C. virginianum	14541	NI†	Colombia	11.48

Source: International Livestock Research Institute (ILRI) forage diversity gene bank; †NI, no information available;

Crop husbandry practices (hoeing, weeding etc) were practiced as desired and no chemical fertilizer source was applied. At 50% flowering stage the herbage in the two rows (2 m^2) was harvested and the fresh biomass weight was taken using field balance. The harvested herbage mass was manually chopped up into shorter lengths using sickle and subsample weighing 200g was dried in air draft oven at 65°C for 72 hours to determine herbage DM production. Chopped herbage of the two replications was pooled and mixed and one representative subsample was taken per accession and saved pending chemical analysis after drying.

Chemical Analysis of the Feed Samples and Calculated Values: Dry matter 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 Kjeldahl method and CP was calculated as N*6.25 [11]. Acid detergent fiber (ADF), acid detergent lignin (ADL) and neutral detergent fiber (NDF) were analyzed by the method o f Van Soest *et al*. [12]. *In vitro* Organic Matter Digestibility (IVOMD) was determined by the modified Tilley and Terry method [13]. Crude protein yield (CPY) was estimated as the product of CP concentration and herbage mass [14]. The ME content was estimated from IVOMD using the equation: ME (MJ kg^{-1} DM) = 0.15*IVOMD [15].

Relative Feed Value (RFV): Relative feed value (RFV) is a forage quality index used to rank feeds relative to the typical nutritive value of full bloom alfalfa hay, containing 41% ADF and 53% NDF on DM basis and having an RFV value of 100 which is considered to provide the standard score. The index is useful to compare the potential of two or more forages on the basis of energy intake. Forages with RFV greater than 100 are of 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 suitable parameter is reported to be very useful for practical forage pricing and marketing [16, 17] and was calculated as:

$$RFV = DDM(\%DM) \times \frac{DMI(\%BW)}{1.29} \text{ [Schroeder, 2013; Uttam et al., 2010];}$$

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

$$DDM\ (\%DM) = 88.9 - 0.78 \times ADF\ (\%DM)\ and$$
$$DMI\ (\%BW) = 120 / NDF\ (\%DM)$$

Data Analysis: For DMY and CPY values, 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 or CPY; 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 the data was hence fitted to the following model.

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

Where *Xij* refers to the quality traits considered; μ is the overall mean; *Yi* is the effect of year (replicate) and *eij* being the random error. The GLM procedure of SAS was used for analyzing the data [18] and significant mean differences were declared at P = 0.05 using Least Significant Difference (LSD) test [19].

RESULTS

Herbage Dry Matter (DMY) and Crude Protein (CPY) Yields: The DMY and CPY values were significantly affected by year (P<0.001) and accession (P = 0.05 for DMY; P<0.05 for CPY). The effect of the interaction between year and accession was not significant for DMY (P>0.05). Significantly (P<0.001) higher herbage DMY and CPY values were recorded during Year 2 (10.8 t ha^{-1} and 230.6 t ha^{-1}, respectively) compared to Year 1 (2.2 t ha^{-1} and 47.2 t ha^{-1}, respectively). The herbage DMY was significantly lower (P = 0.05) for *C. pubescens* ILRI 233 (5.3 t ha^{-1}) and *C. pubescens* ILRI 12297 (5.6 t ha^{-1}). On the contrary, comparable and significantly higher herbage DMY values were recorded for the remaining three accessions (P = 0.05): *C. pubescens* ILRI 243 (7.4 t ha^{-1}), *C. plumieri* ILRI 191 (7.4 t ha^{-1}) and *C. virginianum* ILRI 14541 (7.1 t ha^{-1}). Significantly lower (p<0.001) CPY was recorded for *C. pubescens* ILRI 243 and comparable and significantly higher CPY values were recorded for the other four accessions.

Herbage Nutritive Value: The various herbage quality traits for the five Centrosema accessions are presented in Table 2. No statistically significant difference was observed between the five Centrosema accessions for all

Table 2: Herbage DM and CP yields (t ha^{-1}) of selected Centrosema accessions as influenced by year and accession

Factors considered	Factor description	DMY	CPY
Year	Year 1	2.2±0.36a	47.2±9.14b
	Year 2	10.8±0.36b	230.6±9.14a
Accessions	*C. pubescens* ILRI 12297	5.6±0.56ab	124.8±14.45ab
	C. pubescens ILRI 243	7.4±0.56a	99.2±14.45b
	C. pubescens ILRI 233	5.3±0.56b	145.9±14.45a
	C. plumeri ILRI 191	7.4±0.56a	156.9±14.45a
	C. virginianum ILRI 14541	7.10±0.56a	167.5±14.45a

Note: Year and accession means with no superscript letter in common for DMY and CPY are not significantly different (P>0. 05)

quality traits determined (P>0.05). Averaged over the five accessions, the DM and ash contents were 93.3% and 8.2%, respectively. The CP content ranged from 18.9% for *C. pubescens* ILRI 243 to 22.4% for *C. virginianum* ILRI 14541, with overall mean of 21%. The NDF, ADF and ADL contents were 49.9%, 35.7% and 9.4%, respectively. Pooled over the five accessions, the IVOMD was 43.9%, with values ranging from 38.6% for *C. pubescens* ILRI 233 to 50.7% for *C. plumeri* ILRI 191. The overall mean for RFV was 115, with a range of 106.2 for *C. pubescens* ILRI 243 to 126.2 for *C. plumieri* ILRI 191. The ME content ranged from 5.8 (MJ kg DM^{-1}) for *C. pubescens* ILRI 233 to 7.6 MJ for *C. plumieri* ILRI 191, with an overall mean of 6.7 MJ.

DISCUSSION

Herbage DM and CP Yields: The significant difference in mean herbage DMY between the two years could mainly be linked to variations in stand age as herbage mass during the first year is normally low for most of the herbaceous legume species. In an experiment conducted on *C. pubescens* for two years (2001 and 2002), a non significant (P>0.05) inter-annual variation in herbage DMY, with mean values of 4.08 t ha^{-1} for the first year and 4.26 t ha^{-1} for the second year was reported [20] and this contrasts with what was observed in the present study. The herbage yield values recorded during the first year is apparently lower than the values reported for the first year in the study just mentioned, which might be due to environmental differences. On the other hand, the mean herbage DMY recorded during the second year (10.8 t ha^{-1}) lies slightly above the range of 3-10 t ha^{-1}reported for *C. pubescens* [21], but yields for each of the accessions lies within this range.

Nutritive Value: Among the tested species, *Centrosema pubescens* was observed to be the widely studied one across wider environments among the species evaluated. The overall mean for ash content of the five accessions in the present study is higher than values reported for *C. pubescens* [22 - 24], but comparable to those values reported by Aka *et al*. [25], Nworgu *et al*. [26], Soebarinoto *et al.* [27], Medugu *et al*. [28], Nsahlai *et al*. [29] and Larbi *et al*. [30].

As would be anticipated, the CP content of all the accessions were high and well above the 15% level considered adequate to meet requirements of lactating and growth in dairy cows [31]. A wide range of CP values (8.19% - 28.03%) is available in the literature for the different species, which might be associated with differences in species or accessions [32], natural environmental factors under which the forages were grown, forage husbandry systems (planting time, fertilizer use etc.) or season. For example, significant differences in CP content of *C. pubescens* grown under varying levels of phosphorus fertilizer and planting dates was reported by Omokanye *et al*.[33]. In the study reported by the same author, stands of *C. pubescens* forage that received phosphorus at levels of 30 kg ha^{-1} or 60 kg ha^{-1} and samples collected from late planted plots were observed to contain high levels of CP. In the present study, the CP content did not differ between the two years (P>0.05) which indeed is in agreement with observations of Omokanye *et al*. [33].

The overall NDF content in the present study falls within the range of 41.50 [30] and 61.23% [34] observed in the literature and closer to those values reported for *C. pubescens* (Table 3) by various authors [23, 24, 30, 35]. On the other hand, the overall mean NDF value (50.0%) recorded in this study is relatively higher than that reported by Medugu *et al*. [30], reported value being 41.5%, but lower than those reported for *C. pubescens* [29, 34] and *C. pascuorum* [34]. The overall mean ADF content (35.71%) was also similar to that of Medugu *et al*. [30] and Ukanwoko and Igwe [24], but slightly lower than values reported by others [23, 35]. The overall ADL content in the present study (9.42) is similar to those values reported by Valarini and Possenti [23] but higher than those reported by Evitayani *et al*. [35].

Table 3: Nutritive value traits of different accessions of Centrosema (n = 2)

Accession	DM %	Ash	CP	NDF	ADF	ADL	IVOMD	RFV[#]	ME (MJKg^{-1} DM)
		% DM							
ILRI 12297[†]	94. 0	9.0	22.1	47.4	33.6	9.2	44.1	123.8	6.6
ILRI 243[†]	93.2	8.4	18.9	51.4	39.9	11.1	42.6	106.2	6.4
ILRI 233[†]	92.3	8.4	19.9	53.1	36.3	8.8	38.6	108.9	5.8
ILRI 191[?]	93.6	7.3	21.9	46.8	32.7	6.9	50.7	126.2	7.6
ILRI 14541[§]	93.5	8.1	22.4	51.3	36.1	11.2	43.3	110.2	6.5
Overall mean	93.3	8.2	21.0	50.0	35.7	9.4	43.8	115.0	6.6
SE (accessions)	0.6	0.7	2.3	3.4	3.3	1.1	2.4	10.7	0.4
P level	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: NS, non significant; SE, standard error; [#]relative feed value has no unit. [†]Accessions of *C. pubescens*; [?] Accession of *C. Plumieri*; [§]Accession of *C. virginianum*

The fiber content of the accessions evaluated was generally much lower than values reported for commonly used roughage feeds, which is generally higher than 50%. Fekadu *et al*. [5] for example reported NDF concentration range of 65.8-75.6% (n = 131) for barley straw; 65.7-91.5 (n = 72) for maize stover; 57.3-83.2 (n = 118) for sorghum stover; 70.0-86.0% (n = 130) for teff straw and 40.5-86.2 (n = 96) for wheat straw, which clearly indicates the possible limitations in feed DM intake induced by slow digestion The NDF and ADF content of Centrosema accessions in this study compares well with good quality leguminous hay, which according to Kazemi *et al*. [36] contains NDF and ADF values ranging from 47-53 and 31-40%, respectively indicating their potential to be used as a plant source protein supplement to low quality feed resources

A wide range of *in vitro* DM or OM digestibility values were reported for different Centrosema species in several published works consulted, ranging from 32.5% [32] for *C. plumieri* to 64.7% [34] for *C. pascuorum* (Table 3). The pooled IVOMD for the five Centrosema accessions (43.88%) observed in the current study is higher than levels reported for *C. plumieri* (32.5%), *C. arenarium* (41.6%) and *C. brasilianum* (42.4%), but closer to those reported for *C. macrocarpum*, *C. acutifolium*, *C. virginianum*, *C. pascuorum* and *C. schottii* [32]. Averaged over the five accessions, relatively lower IVOMD was observed in this study compared to those values reported for *C. pascuorum* [37]. Generally, the digestibility values observed in the present work is lower than the threshold value of 50% required for feeds to be considered as having acceptable digestibility [38] and also inferior to those values reported earlier for other herbaceous (65%) and browse (55%) legume species in Ethiopian [7]. The diverse range of values observed in the literature can be linked, among others, to genotypic and environmental differences. The overall mean RFV index of around 115 observed for the Centrosema accessions in this study falls within the range of 103-124 that leguminous hays of second grade quality are required to have [36, 37]. In fact the magnitude of the index is higher than a standard value of 100 implying the higher quality status of the accessions [16]. Similarly, the mean ME value of 6.6 MJ for the Centrosema accessions is slightly lower than the critical threshold of 7.5 MJ [38] and the value that was reported earlier (10 MJ) for other protein supplements [39]. Among the accessions tested, *Centrosema plumieri* ILRI 191 was observed to have ME value closer to the threshold level of 7.5 MJ, indicating it's potential to be considered for further evaluation in the next stage of varietal evaluation.

In conclusion, based on DM and CP yields and the quality attributes assessed, three of the top ranking accessions that combined high biomass and crude protein production potential were: *C. plumieri* ILRI 191, *C. pubescens* ILRI 12297 and *C. Virginianum* ILRI 14541. These three accessions can further be promoted to the next variety verification stages to finally identify one or two of the best performing Centrosema genotypes for release as variety.

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